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SCHOOL SCIENCE AND MATHEMATICS

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INSECT NATURE-STUDY.[1]

BY C. F. CURTIS RILEY,

Department of Zoology, University of Manitoba, Winnipeg, Canada.

Insects are at all times interesting and desirable forms for nature-study work. They are beautifully colored, and thus appeal to the aesthetic side of our natures. Their remarkable adaptations to environmental conditions form a source of constant wonder. The instincts, habits, and other types of behavior of these creatures ever have offered bewildering problems to the naturalist; while the truly wonderful transformations of insect life, by means of physical metamorphosis, are as remarkable today as when first investigated.

In the early spring, the first active insects are noticed with considerable interest. One of the first butterflies to appear is the Mourning Cloak, *Vanessa antiopa* (Fig. 1). This insect has been observed by the writer in the vicinity of Milwaukee, and also in the southern part of Minnesota, as early as the first and second week in March. It is also occasionally seen on warm, sunny days in winter. Its color, on the upper surface, is purplish

[1] This paper treats of certain phases of insect life and of environmental conditions, mainly as they exist in temperate America. Although the majority of the statements made therein have been verified, the writer wishes to acknowledge his indebtedness to the following works:

Comstock, J. H., *Insect Life* (ed. in colors; New York: D. Appleton and Co., 1919), 6+349 pp., 18 pls., 296 figs.

Comstock, J. H., and A. B., *A Manual of the Study of Insects* (17th ed.; Ithaca, New York: Comstock Pub. Co., 1923), xi+701 pp., 6 pls., 797 figs.

Folsom, J. W., *Entomology* (3d. rev. ed.; Philadelphia: P. Blakiston's Son and Co., 1922), vii+502 pp., 5 pls., 308 figs.

Linville, H. R., and Kelly, H. A., *A Text-Book in General Zoology* (Boston: Ginn and Co., 1906), x+462 pp., 1 pl., 233 figs.

Lutz, F. E., *Field Book of Insects* (New York: G. P. Putnam's Sons, 1918), ix+509 pp., 101 pls.

Peckham, G. W., and E. G., "On the Instincts and Habits of the Solitary Wasps," *Bull. Wis. Geol. Nat. Hist. Surv.*, no. 2, sc. ser. no. 1 (1898) iv+245 pp., 14 pls.

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Thanks are due to Mr. H. Johnson for assistance in making the drawings from which are reproduced Figs. 10, 11, 17.

Appreciation is given to Mr. A. E. Field for excellent photography.

brown, with the wings margined with yellow, and just within the margin of yellow a row of blue spots. The common Cabbage Butterfly, *Pieris rapae* (Fig. 2), is another insect that appears early in the year, frequently being observed by the middle of April. It may be identified by the dull white color of the wings, on the upper surface, marked with small black spots, and the lemon-yellow color of the under surface of the wings. If sheltered ponds and streams are visited in March, the water-

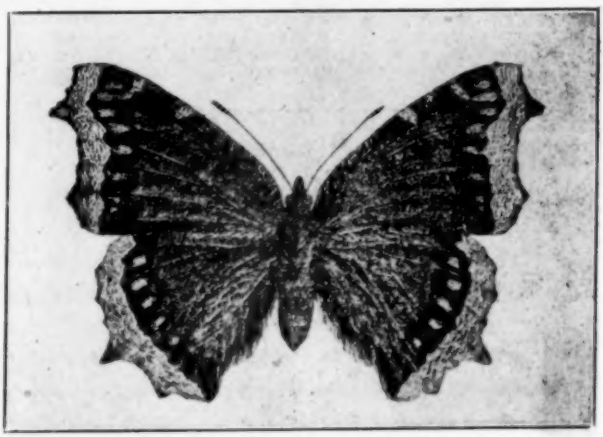


FIG. 1.—MOURNING CLOAK, *Vanessa antiopa*, HIBERNATES IN ADULT FORM; MAY APPEAR, IN SPRING, AS EARLY AS FIRST WEEK IN MARCH. SLIGHTLY REDUCED—AFTER COMSTOCK.

striders (Fig. 3) may be seen skating over the surface of the water. Some species of these insects are black, and others are brown in color, with elongated bodies, and long slender legs. Many of the common ground-beetles appear early in the spring. On warm days, they may be found crawling on the ground among the dead vegetation. They leave their underground haunts and come to the surface for light and warmth. They frequently are observed under dead leaves in the woods. It is not uncommon to surprise them beneath stones and decaying logs. The little red ants are among the first visitors, for as early as the middle of April, they are busily engaged in our gardens and on our lawns.

When insects first appear in the spring, we wonder from whence they come. The abiding places of these creatures during the winter months are many and varied, and to the true nature-study student suggest an interesting field for investigation. Such work, however, requires *real interest*, perseverance, and disregard of physical inconveniences. The Mourning Cloak

butterfly hibernates in the woods, under dead leaves, and in hollow trees. The water-striders pass the winter under deep drifts of dead leaves, under rocks and stones near bodies of water, and under the over-hanging banks of streams in protected situations (Fig. 4). Many beetles burrow into dead logs and trees,

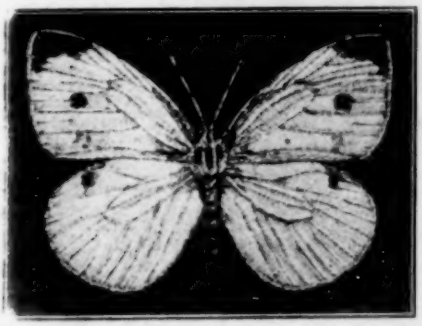


FIG. 2.—CABBAGE BUTTERFLY, *Pieris rapae*, APPEARS AS EARLY AS FIRST OR SECOND WEEK IN APRIL. NATURAL SIZE.—AFTER COMSTOCK.

and securely pass the winter in such places. Many species of small insects crawl into depressions under the bark of trees, and thus escape the cold. While it is true that many thousands of insects perish every winter, it is equally true that enormous numbers hibernate in perfect security until the spring.

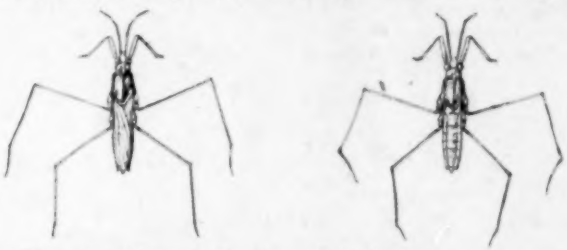


FIG. 3.—WATER-STRIDERS, *Gerris remigis* SAY; WINGED FORM TO LEFT; WINGLESS FORM TO RIGHT. NATURAL SIZE.—COURTESY EDITOR ANNALS ENTOMOLOGICAL SOCIETY AMERICA.

Insects, in a general way certainly, are adapted to the environment in which they live. Their habits and instincts vary considerably. Knowing these facts, we should expect to find different species of insects in different locations—different habitats. Our own gardens are excellent places to obtain insects, and this is particularly true of the vegetable garden, which discloses many species of true bugs, beetles, butterflies, bees, wasps and flies. It is believed by certain writers that the colors of flowers attract some of these insects. It is certainly true that many are found there sipping nectar from the flowers. On

FIG. 4.—DETAIL OF BANK AND POOL OF BROOK—CURRENT FLOWS TO RIGHT—NEAR WHITE HEATH, ILLINOIS—AUTUMN. SHOWS UNDERCUTTING OF BANK, ROOTS OF TREE, AND CLUMP OF DEAD LEAVES—MAINLY OAK—TWO TO THREE FEET IN DEPTH AND SIX TO EIGHT FEET IN LENGTH; WATER-STRIDERS, *Gerris remigis* SAY, HIBERNATE IN ALL THESE SITUATIONS, FREQUENTLY FOUND IN LARGE NUMBERS UNDER DEAD LEAVES CLOSE TO WATER.—COURTESY EDITOR ANNALS ENTOMOLOGICAL SOCIETY AMERICA.

the fruit and shade trees may be observed caterpillars, plant lice, scale insects, and various other kinds of bugs. On the ground, under logs, boards and stones, are found crickets, ants, beetles and cockroaches. Meadows and pastures produce various species of crickets, locusts, grasshoppers, butterflies and bees. Many of the smaller species of dark-colored moths are

often found fluttering among tall grass stems and weeds. Wooded regions are inhabited by many different kinds of dark-colored insects. Among these may be mentioned several species of butterflies and moths. Beetles, bugs and bees also live in such situations.

FIG. 5.—CRANE-FLY, OR DADDY LONG-LEGS, OF THE FAMILY TIPULIDAE; LARVAE SHOW REMARKABLE HABITAT ADAPTATION. THESE FLIES OFTEN MISTAKEN FOR MOSQUITOES. ABOUT NATURAL SIZE.—AFTER FOLSOM.

Many nature-study students find aquatic insects to be even more interesting than those that live on the land. There is, perhaps, a truer perfection of adaptation among the former. It is not realized always that aquatic insects are distributed among many distinct groups. Among insects that are aquatic or semi-aquatic, during some period of their lives, we find May-

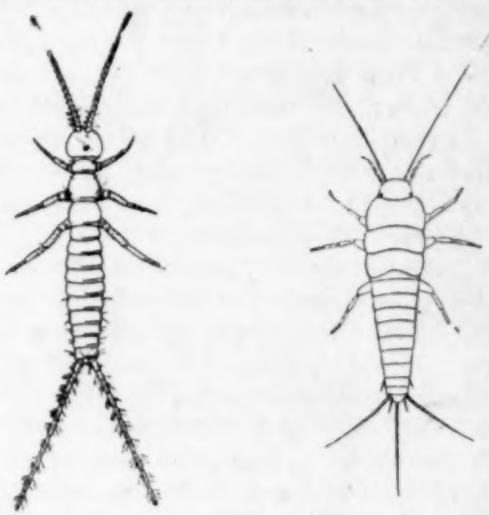


FIG. 6.—INSECT TO LEFT BRISTLE-TAIL, *Campodea;* INSECT TO RIGHT FISHMOTH OR SILVER-FISH, *Lepisma.* BRISTLE-TAILS AND FISH-MOTHS BELONG TO THE ORDER THYSANURA; ALL ARE TERRESTRIAL FORMS. MUCH ENLARGED.—AFTER FOLSOM.

flies, stone-flies, dragon-flies, damsel-flies, caddis-flies, twisted-winged insects, bugs, beetles, flies, springtails, and also examples of groups to which the butterflies and bees belong. It is of interest to know that the transition from land habits to water habits has come about very gradually, through a long period of time. The behavior of certain common insects throws some light upon this subject. There are long-legged flies known as tipulids

FIG. 7.—WATER-SCAVENGER BEETLE, *Hydrophilus triangularis*, SHOWING SMOOTH DORSAL SURFACE AND FLATTENED HIND LEGS. NATURAL SIZE.—AFTER FOLSOM.

(Fig. 5), which develop from larvae possessing habits which indicate remarkable habitat adaptation. Some of these tipulid larvae live in soil which is comparatively dry; others are found in moist earth; while many inhabit a soil saturated with water, and adjacent to a pond or stream; and still others are entirely aquatic. These transitional habitats and the associated types of behavior can not but have a bearing upon the change of adaptation from the terrestrial to the aquatic habit.

The theory was held formerly that insects inhabiting the land had evolved from those living in the water, but the best evidence today seems to indicate that the terrestrial insect is the more primitive type. On close examination, we find, without question, that aquatic insects possess the land type of structure. While it is a fact that there are many adaptations for the purpose of aquatic life, there is no geniune obscuration of the terrestrial type of structure; for it is evident that the morphological modifications are not great, nor are they of a permanent character. In this connection, it is of interest to recall that the members of the most primitive group of insects are all land forms. We refer to the order Thysanura (Fig. 6), to which belong the bristle-

tails and fish-moths. There are about one hundred and seventy-five species of insects in this order; and all of these have a simple generalized plan of structure, and none of them live in aquatic habitats.

Some of the structural adaptations of aquatic insects are of great interest and well worthy of notice. One of our large water beetles, *Hydrophilus triangularis* (Fig. 7), presents certain characteristic features somewhat similar to those of a boat, and its long legs are not unlike oars. The body has a smooth, polished external surface which lessens friction as the creature swims through the water. The legs of this insect are wide and flat, the lower part—the tarsal region—being fringed with long hairs (Fig. 8). As it swims, the so-called "stroke" is made by the flattened side of the legs, assisted by the hairs which spread widely, thus offering greater resistance to the water. When the next movement—the "recover"—occurs, the legs are twisted, so that the narrow edge cuts through the water, and the hairs assume a position close against the tarsi, the result being a reduction in the resistance. If the beetle is placed in a glass dish of water and watched carefully, it will be evident that the last pair of legs are used in swimming, as they are nearest to the center of gravity. Now drop a terrestrial beetle into the dish of water and notice that the creature instinctively depends upon the third pair of legs for locomotion. Not all aquatic beetles use their legs in the same manner when swimming, for example, *Hydrophilus* moves its hind legs alternately, but the Predaceous Diving-beetle, *Dytiscus* (Fig. 9), a member of the family Dytiscidae, operates its hind lets simultaneously. The second method of swimming is superior to the first, because it results in locomotion in a straight path, and eliminates much waste motion. The adaptiveness of the legs of aquatic beetles, for locomotion in water, is indicated very well when such insects are placed upon a solid surface. They stumble about most awkwardly, making vain attempts to walk, for the modifications of the legs for swimming have impaired them for walking purposes.

There are many other morphological modifications of the bodily form of insects, which seem to indicate the adaptation of these creatures to an aquatic life. With these modifications of structure are associated special kinds of behavior; several of these will be considered. Various species of bugs live in ponds and streams. One of these is known as the Giant Water-bug,

Serphus, and is frequently observed carrying the eggs on its back. It is the male insect that evinces this form of behavior. It was formerly believed that the female placed the eggs on her own back. One important fact that throws doubt on this idea is that the ovipositor of the female *Serphus* is of such a structure that it could not be used for the purpose mentioned. The process by which the eggs are placed on the back of *Zaitha*, a closely related water-bug, is definitely known, for the egg-laying has been observed in aquaria. One layer of eggs is placed on the back of the male, and the eggs are so arranged that the long axes are perpendicular to the back of the insect, being held in position by a mucilaginous-like substance. The male bug responds negatively to this operation; in other words, it is not passive during the procedure.

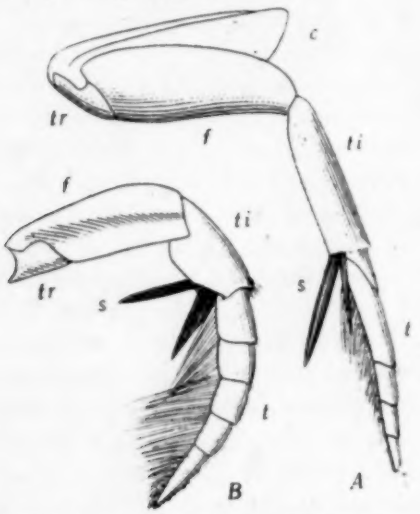


FIG. 8.—LEFT HIND LEGS OF AQUATIC BEETLES, SHOWING FRINGE OF LONG HAIRS ON TARSI. A, WATER-SCAVENGER BEETLE, *Hydrophilus trangularis;* B, PREDACEOUS DIVING-BEETLE, *Cybister fimbriolatus*, WITH TARSAL HAIRS WELL DEVELOPED; C, COXA; F, FEMUR; S, SPUR; T, TARSUS; TI, TIBIA; TR, TROCHANTER. MUCH ENLARGED.—AFTER FOLSOM.

The process of respiration among aquatic insects is frequently associated with structures and organs that appear to be specially modified for the performance of this function. Some insects must come to the surface of the water to breathe; others find it possible to take air under their wings, and to carry it below the surface; many have specially adapted structures known as gills, which are able to obtain air from the water in which the insects live. The Water-scorpion, *Ranatra* (Fig. 10), lives in quiet water, near the shores of ponds and banks of

streams. This insect is brown in color, with long, slender legs and body. It comes to the surface of the water to breathe; this it is able to do by means of two elongated, delicate bristle-like structures situated at the hind extremity of the body. These organs are locked together during the process of respiration and thus form a single tube, which is projected to the surface of the water, from whence the air is taken into the body of the insect. Frequently, this tube is thrust to the surface of the water during respiration, while the Water-scorpion is at the bottom of a shallow stream or pond; or the creature may be nearer to the surface, grasping the stem of some aquatic plant. The Back-swimmer, *Notonecta undulata* (Fig. 11), is an interesting insect. As its name suggests, it swims on its back, which is shaped rather similar to the bottom of a boat. Hairs are distributed over the external parts of the body, and among these a film of air is entangled. The insect also takes air into the space under the wings. This air, in the two places mentioned, is carried beneath the surface of the water, and it allows the back-swimmer to remain there for a considerable length of time. The Whirligig-beetle, *Gyrinus*, which is often observed circling around on the surface-film, is able to swim below the water-surface with a sac of air attached to the hind end of the body, thus permitting the insect to breathe in deep water. The members of a related genus of whirligig-beetles, *Dineutus* (Fig. 12), are able to respire under water, owing to the air taken under the elytra or wing-covers. During the larval and nymphal stages of certain aquatic insects, the skin is sufficiently thin that respiration occurs by direct aëration. The nymphs of damsel-flies possess specialized structures for breathing, that are in reality outgrowths from the skin. They have leaf-like gills (Fig. 13) at the tip of the abdomen, which are thin-walled and contain many delicate, branches tubes. Pure air is taken in from the water, and then circulates through these tubes. Many immature forms of insects, with organs of respiration of this character, can remain below the surface of the water indefinitely. Other examples of adaptation of structure in connection with function could be designated, but perhaps sufficient has been stated to indicate something of such modifications among aquatic insects.

Many students of insects are very much interested in making collections, and in mounting insects on pins. Such work has its value and its attraction, and must not be decried; but to

the writer, there is much greater fascination in the living, breathing organism. A new science has developed in recent years, which is known as *Animal Behavior*. This is the study of the responses of living animals, in a logical manner, and, as far as possible, the discovery of satisfactory explanations for such responses. Much of this sort of work has been done in our laboratories, under what is known as controlled conditions

FIG. 9.—PREDACEOUS DIVING-BEETLE, *Dytiscus*, DORSAL VIEW; ADAPTIVENESS TO AQUATIC HABITAT INDICATED BY GENERAL STRUCTURE OF BODY. NATURAL SIZE.—AFTER LINVILLE AND KELLY.

The results of such work have proved to be of great value. But there is also much valuable investigation to be accomplished in the observation and interpretation of animal responses out-of-doors, where animals are found in their natural environment. Insect life is well adapted for investigations from the viewpoint of the student of *Animal Behavior*.

The responses of insects that have been studied most carefully are those known as tropisms, instincts, and intelligence. Certain influences of the environment, for example, temperature, moisture, gravity and light, frequently have a controlling effect upon the direction in which an insect moves, and these factors also may determine its bodily orientation. The response of an insect, under such conditions, may be stated to be a tropic response, or a tropism. Certain species of beetles respond to the stimulus of moisture by moving toward it. When insects move toward the source of the stimulus, they are said to respond in a positive manner. On the other hand, when they move away from the source of stimulation, they are responding in a negative way. Certain aquatic beetles were

removed from the water, while clinging to some water plants; when the plants were placed on the ground, they scrambled out, and made their way toward the water, which was about twenty feet distant. There are beetles that dwell on the shore and keep themselves carefully concealed. If water is splashed near the place of concealment, they leave their haunts and may be captured. Each instance is an example of response to

FIG. 10.—WATER-SCORPION, *Ranatra;* AN AQUATIC BUG, SHOWING LONG, SLENDER, BRISTLE-LIKE RESPIRATORY STRUCTURES AT HIND EXTREMITY OF BODY. NATURAL SIZE.—DRAWING JOHNSON AND RILEY.

moisture, and is known as a tropic response. Behavior of this character is named hydrotropism. Some insects avoid the light, for example bedbugs and cockroaches. Many butterflies and moths fly toward the light. Both of these are cases of phototropism. The direction of locomotion appears to be guided by the stimulus of the light. Much detailed experimental data have been assembled, and careful conclusions have been made upon various kinds of tropisms.

Instinct is a type of behavior that is well developed among insects. All forms and types of behavior are rather to be considered as processes than as products. Frequently, instinct appears to be so complete and so finished a process that it is suggestive of rationality. However, instinctive behavior may be considered to be of that character which "attains adaptive

ends without prevision and without previous experience." Another brief definition of instinct is "a propensity prior to experience and independent of instruction." A butterfly deposits its eggs upon a food-plant of a particular kind. All butterflies of the same species deposits their eggs upon plants of this same kind. This act is accomplished, the first time

FIG. 11.—BACK-SWIMMER, *Notonecta undulata*, COMMON IN PONDS, AND IN POOLS OF SLUGGISH STREAMS. NATURAL SIZE.—DRAWING JOHNSON AND RILEY.

certainly, without prevision and without experience. Caterpillars of a like species build nests which are all alike in structure. This can not be the result of imitation, for the individual caterpillars each build the same kind of a nest even when widely separated from each other. This is an instinctive act, as there is no indication of prevision, and experience with respect to

FIG. 12.—WHIRLIGIG-BEETLES, *Dineutus*, ON SURFACE OF WATER. COMMON ON SURFACE-FILM OF PONDS AND SLUGGISH STREAMS. NATURAL SIZE.—AFTER LINVILLE AND KELLY.

the process is excluded. Flesh flies very soon after emerging from the pupae cases are able to perform the various life processes. Their sense of smell directs them to the proper food. They are able to avoid many different kinds of harmful stimuli. The members of the opposite sex are readily recognized. Their eggs are deposited on the kind of substances that will serve as food for the larvae, that are to be hatched from these eggs. None of these acts have been directed by former experience;

neither are they prompted by reason. All of this behavior is the result of impulse, which urges these creatures to use their energy in certain definite ways. They do not know why they perform these acts.

FIG. 13.—LEAF-LIKE GILLS OF DAMSEL-FLY NYMPH, ZYGOPTERA. ENLARGED.—AFTER FOLSOM.

Some instinctive acts appear to be practically inflexible; others display definite indications of flexibility. The fact that instincts are modifiable suggests the possibility of variation in instinctive behavior, and this has been found to be the case. Certain solitary wasps, *Ammophila*, place caterpillars in their nests. After capturing the caterpillars and before dragging them into the nests, the wasps sting these larvae in order to paralyze

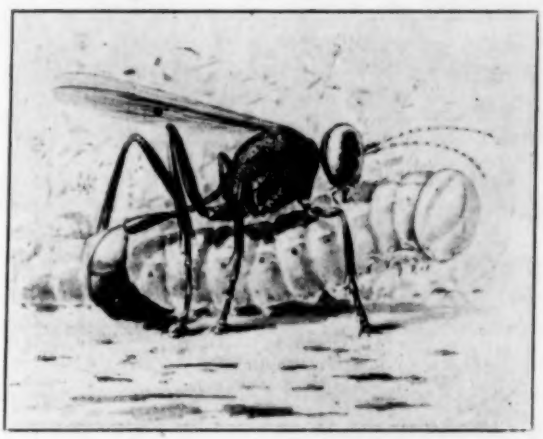


FIG. 14.—SOLITARY WASP, *Ammophila urnaria*, STINGING CATERPILLAR, BEFORE CARRYING TO NEST. ENLARGED.—AFTER G. W. AND E. G. PECKHAM.

them (Fig. 14). On examining these caterpillars, and after observing the wasps in the act of stinging, it was found that there was much variation in this process. In fact, in no instance was the sting given without some variation. There was much variability in the severity of the stinging, for some of the caterpillars lived only two or three days, while others were alive at the end of two weeks. There was also considerable variation in the method of digging the nest, as there was also in the final shape of it.

One of the most interesting phases of *Ammophila* behavior, in connection with the work on the nest, is that of filling up the cavity. There is much variation in the character of the responses. In fact, it may be stated that "the character of the work differs with the individual." There are at least five different variations of behavior in closing the nest. However, one of these is much more remarkable than the others, both as to its adaptability and its individuality. After the cavity of the nest had been filled up to the level of the ground, one *Ammophila*

FIG. 15.—SOLITARY WASP, *Ammophila urnaria*, WITH PEBBLE IN MANDIBLES FOR POUNDING DOWN EARTH ABOVE NEST. ENLARGED.—AFTER G. W AND E. G. PECKHAM.

carried some small particles of soil to the locality of the nest. Immediately following this act, the wasp, by means of its mandibles, seized a small stone (Fig. 15) and used this to pound down these particles of soil, until the closed mouth of the nest was as smooth and firm as the surface of the ground in the immediate vicinity. It is, of course, possible that the response of the wasp, in pounding down the soil with a small stone, was an intelligent act. In fact, the original observers (1898, p. 236)[2] considered the behavior to be of this character. Many other examples of modifiability in instinctive behavior could be given. However, it has been sufficiently indicated that not all instincts are inflexible, neither do they lack individuality.

The origin of instinct is an interesting problem, and it has been discussed at great length by many students of *Animal Behavior*. The instinctive acts of insects are of the reflex type; they may be considered to be co-ordinated reflex acts. In fact,

[2]Peckham, G. W., and E. G., "On the Instincts and Habits of the Solitary Wasps," *Bull. Wis. Geol. Nat. Hist. Surv.*, no. 2, sc. ser. no. 1 (1898) iv+245 pp., 14 pls.

it is very difficult to distinguish clearly between reflexive and instinctive behavior. They possess at least one trait in common, and that is their adaptiveness. Reflex acts are responses of specific organs of the body of insects, which owe their origin to various kinds of stimuli. These responses may be considered to be inevitable, and entirely lacking in volition. The fact that insects possess organs presupposes their use. The function of stinging is a reflex act, for a wasp that has been decapitated still

FIG. 16.—*Polistes*, A GENUS OF WASPS LIVING IN COLONIES. NATURAL SIZE.—AFTER COMSTOCK.

has the potency to perform this act. A wasp that has recently emerged from the larval stage stings with precision. It is stated by some writers that a reflex act is the response of an organ, while an instinctive act involves the entire body of the insect. But it is well known that the behavior of many of the simplest animals is of the reflex type, and yet the whole body is involved. There is a close relationship between an insect tropism and an insect instinct. In fact, an instinct, not incorrectly, could be defined as a tropism or a combination of tropisms.

Instinct has been designated as inherited habit, but this explanation of instinct is not widely accepted. Another viewpoint of instinct is that it is "lapsed intelligence." Such an assumption of the origin of instinct necessitates farther consideration of habit. In many instances, habits are, undoubtedly, the product of intelligent behavior. According to such a point of view, the constant repetition of behavior of this character gradually develops into self-regulatory acts, resulting finally in instinct. Such a view of the origin of instinct would require intelligence to have appeared first, and instinct to have degenerated from it. To the evolutionist, such an idea is untenable, because it is illogical; for the lowest, simplest, animals would be expected to be devoid of instinct, and their behavior to be almost

entirely of the intelligent type. Students of genetic animal psychology and behavior know that the opposite is the case. The preponderance of evidence points to the probability that instinct has developed from reflex acts, because among the lowest animals, it is found that their behavior is very largely of the reflex type; and as we pass up the scale of animal life, instinct is observed to be the outcome of this type of behavior, having reached a very high stage of development among insects. Some of the social insects, such as bees, wasps and ants, not only evince complex and specialized instincts, but also a certain amount of intelligence. Finally, among the higher vertebrates, although there is much behavior of an instinctive character, intelligence reaches its culmination, having evolved from behavior possessing an instinctive basis.

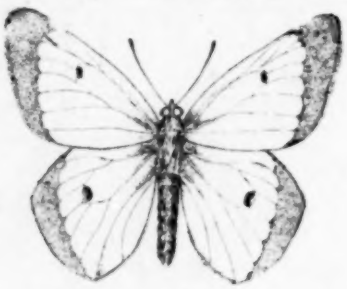


FIG. 17.—COMMON SULPHUR, *Colias philodice*, A BUTTERFLY FREQUENTLY DISPLAYING ALBINISM. NATURAL SIZE.—DRAWING JOHNSON AND RILEY.

Intelligent behavior differs from both tropisms and instinct. It is demonstrated in the ability of an insect to profit by experience, which is an indication of intelligence. There is a considerable amount of evidence of intelligent behavior among insects as shown in their power to choose between alternatives. Discrimination is proved, as the result of experience, by their skill in avoiding enemies, in their fine control of locomotion, in their choice of food, and in their wonderful power of intercommunication. Many of the acts of solitary wasps are intelligent. Social Hymenoptera, the group to which belong the wasps, bees and ants, exhibit behavior which is very difficult to explain, except from the standpoint of intelligence. Much has been written concerning imitation among the Hymenoptera; but how much of this sort of behavior there is among the various species of wasps is doubtful. Certainly, there is no indication that worker wasps, *Polistes* (Fig. 16), learn to feed the young by imitation. An example of intelligence among

insects is the precision with which bees find their way back to their nest. There is, probably, no mysterious direction sense involved in order to explain such behavior, for there is reliable evidence that these insects find their way by the recognition of objects along the route traveled. Careful observation has proved that when bees leave the nest for the first time, they make vigilant studies of the immediate vicinity. Ants readily recognize members of their own and of other colonies. This behavior may easily be mistaken for intelligent discrimination, but it is not necessary to consider these insects endowed with intelligence, in order to interpret correctly responses of this character. Such recognition is the result of being able to distinguish the distinctive odor of individuals of their own colony, and that of the members of other colonies. In closing this topic, it may be stated that there is great difficulty in drawing a sharp line of demarcation between instinct and intelligence. Many responses of insects are without doubt largely of the instinctive type, but there is much behavior that just as surely involves intelligent acts.

Even the casual observer has noticed the brilliant colors of many insects. In many cases, it is the aesthetic appreciation of insect coloration that first attracts nature students to these interesting creatures. The colors of insects may be considered as being due to three factors: internal pigments, interference or reflection of light resulting from certain structural conditions, and combination colors due to the two factors mentioned acting together. The beautiful iridescence of the wings of flies and that of soap bubbles are formed practically in the same manner. The irridescence observed in the colors of the scales of butterflies, in many instances, is produced by the diffraction of light by means of fine, closely parallel markings. Beetles are often blue or green in color; these striking colors are frequently the result of the diffraction of light, produced by means of very small lines or pits. Cockroaches and many beetles owe their colors very largely to the pigment in the cells of the skin layers. There are a number of other factors that modify colors in insects, such as the effects of light and darkness, moisture and dryness, food and lack of food, and also heat and cold. It is well known that the insects of the tropics are brilliantly colored, and that the colors of insects in the far north are dull and monotonous. The former is generally considered to be the result of high temperature, bright light and excessive moisture.

The latter is probably the consequence of environmental, climatic conditions. Such coloration is described as being climatal.

The nature-study student should learn to discriminate between the light-colored and the dark-colored insects. Some are exceptionally white or pale in color, which may be owning to lack of pigment, or to the presence of a white pigment. This is known as albinism, and is common in certain species of butterflies. The common yellow butterfly, known as *Colias philodice* (Fig. 17), and the Cabbage Butterfly, which belongs to the family Pieridae, frequently display albinism. Other species of butterflies are almost black in color, while still others are dark brown. This is believed to be the result of high temperature and moisture, and is a condition known as melanism. Some species of butterflies produce three broods in a year, one

FIG. 18.—SPRING AZURE, *Cyaniris pseudargiolus*, A SMALL BLUE BUTTERFLY PRODUCING THREE VARIETIES IN A SEASON; A, VARIETY *lucia*, LARGE BLACK MARKINGS ON UNDER SURFACE; B, VARIETY *violacea*, SLIGHTLY LARGER, SMALLER BLACK SPOTS; C, *pseudargiolus* PROPER, STILL LARGER, FAINT BLACK DOTS. REDUCED.—AFTER FOLSOM.

in the spring, another in the early summer, and still another in the late summer; all three of these differ markedly in color. This variation in color of the same species, in different broods, is finely exemplified by a small blue butterfly, the Spring Azure, *Cyaniris pseudargiolus*. It is very common in many parts of New England, where two broods are produced. In the vicinity of Cambridge, Massachusetts, the spring brood yields two varieties, an early one, known as *lucia*, small in size, with large black markings on the under surface; and a late one, named *violacea*, generally larger than the first, with smaller black spots on the lower surface of the wings. The summer brood produces a third variety, which may be considered as *pseudargiolus* proper, larger than the two other varieties, and with the black dots indistinct on the under wing-surface (Fig. 18). It is an interesting fact that, in the northern parts of Canada, there is one brood only, *lucia;* while, in the warmer parts of the southern United States, there is but one variety in the spring, *violacea;* the later variety is *pseudargiolus*. Such difference in coloring, in the same species, is known as seasonal coloration.

The study of insects and the habitats of insects, if steadily pursued, will give the nature-study student an appreciation of outdoor life that can not readily be obtained in any other way. It will develop keen observation and quicken the ability to discriminate between likenesses and differences. The student will gradually become acquainted with a vast faunal life, which he scarcely knew to exist. Finally, he will touch at first hand, some of the great truths of organic life, exhibited as fundamental laws and principles, which govern the relations and interrelations of the various units of the realm of nature.

THE NEW METHOD OF BIRD STUDY.

Do you know the fascination of trapping and banding wild birds? Have you held a bird in your hands, examined him carefully, released him, and then found that, instead of being frightened away, he comes back to your traps again and again; sometimes the same day, the same week; perhaps he reports to you nearly every day all summer; yes, and some of them year after year.

Professional or amateur ornithologist, you may by this method handle hundreds of birds in a year, study the bird, his habits, his mates, and even keep a record of his children, or grandchildren. By this method you may secure new kinds of facts, that were formerly so difficult to obtain. And this is no guess work, for each bird is identified by the number on the small aluminum band, which you have attached to his leg when first taken.

A trapping and banding station benefits and increases the number of birds, as success requires that the locality be freed of the enemies of birds; that food and shelter be provided, and the locality becomes in fact a bird santuary, Many officers of Audubon Societies are recommending this method, not only as the best means of increasing popular interest in birds, but because it directly benefits and increases the number of birds.

This method of bird study has been adopted by the U. S. Biological Survey (Washington, D. C.), and Special Permits for Bird-banding are issued to those who will volunteer to place the bands which are furnished by the Survey. These Permits are issued only to persons over eighteen years of age who have sufficient experience and knowledge of brids to carry on the work with scientific accuracy.

The Inland Bird-Banding Association was organized in Chicago in October, 1922, for the purpose of assisting and co-operating with the Biological Survey in organizing this work in Canada, the Central States and the States of the Mississippi Valley, from the Appalachian Mountains to the Rocky Mountains and south to the Gulf of Mexico.

The purpose of this association is to bring together those who are interested in the study and protection of birds along the great migration routes in this area, to assist in organizing trapping stations, to encourage local meetings of those who are interested, and provide a central office of exchange of information and ideas; members will be expected, when they file reports with the Biological Survey, as required by the Survey, to furnish quarterly a general report to this Association.

If you are interested, send in your application to the Treasurer.

WILLIAM I. LYON, *Secretary*,
124 Washington St., Chicago, Ill.

HIGH SCHOOL CHEMISTRY AND THE PERIODIC SYSTEM.

P. M. GLASOE, PH. D.,
St. Olaf College, Northfield, Minn.

Science is systematized knowledge, says the dictionary. If that be the case it should be good pedagogy to give the subject a touch of "system" just as early as possible. We pride ourselves on the fact that chemistry is not only a science but an accurate science. It is, therefore, good teaching strategy to give the study a distinctly chemical atmosphere just as soon as possible.

Suppose a chemist should say to you that he does not believe in dividing the metals into the five or six groups usually used in qualitative analysis—it is too mechanical and difficult; it requires the memorizing of a number of metals in Group I, another series in Group II, etc. No, he wants his students to go into the laboratory and work out for each metal a series of tests and reactions by which it may be identified.

An intolerable attitude, you say, and one that will not bring results. And yet that is the attitude a lot of people take to the Periodic System—nature's own golden thread running through first year chemistry. Just what there is about it that makes it so difficult that it must be shut out of high school chemistry is not at all apparent to a person who has given the System thorough study. Leaving it out makes first year chemistry a veritable potpourri.

Can the Periodic System be Grasped by High School Students?

It is much simpler than the multiplication table. It is immensely more interesting and requires much less time for mastering it. There is absolutely nothing difficult about it. Moreover, every phase of the learning of it may be made very interesting and highly profitable. It gives the opportunity of introducing a lot of knowledge which every intelligent high school student already has—putting their knowledge to work, so to speak, in a practical and thought producing way. It arouses a sense of curiosity, gives the imagination free play and serves to connect the most fundamental facts so as to make of first year chemistry a united and well rounded whole instead of a heterogeneous jumble of disconnected facts and figures.

When Should It Be Introduced?

Early. *Very early.* Surely you will allow us "to follow the order of topics which has become standard in chemical teaching" through time worn custom, taking up oxygen, hydrogen, water,

chlorine, sodium, the atmosphere and nitrogen before entering upon any such sweeping generalization as the Periodic System? Emphatically, No! Why should anyone want to take up the above disconnectedly, without any show of relationship at all, when one can just as well take them up later with some show of sequence and consequence?

All you need is to lay the usual foundation by taking up the consideration of chemical and physical change, compound and mixture, and the law of definite composition. From this you go naturally into the consideration of the ultimate chemical units, the atoms, and their weights, and that is all that is necessary. Having shown the class that they already know a good many chemical elements by having them name all the metals they are acquainted with and calling their attention to the fact that such substances as sulphur, charcoal, chlorine, and iodine are also elementary you direct their attention to the table of atomic weights found in the text book and make the class do the preliminary work in beginning the study of the Periodic System.

How to Begin.

Let the class arrange the first eighteen or twenty elements *in the order of their atomic weights.* Several of the first twenty are new and strange to them but a surprising number will be found to sound familiar. You show them samples of sodium, magnesium, aluminum, carbon, phosphorus, and sulphur. A mere suggestion on the part of the teacher brings out the distinctly opposite characteristics here shown. Magnesium and aluminum are metals; well, what shall we, then, call carbon, phosphorus, and sulphur? If they cannot suggest the name themselves they will instantly agree that "nonmetal" will be a good name for them. So also they can be made to see that nitrogen, oxygen, and fluorine are nonmetals while lithium, beryllium, and boron are metals. It will be an interesting exercise for them to note that they first have two nonmetals, hydrogen and helium, then three metals, then five non metals, then three metals and again five nonmetals—periodicity already. Thus:

Two nonmetals	Three metals	Five nonmetals	Three metals	Five nonmetals

Now, why shouldn't that appeal to a wide awake class of boys and girls? They have made a scientific discovery. Taking the elements *in the order of their atomic weights* there appears and

reappears with wonderful periodicity a certain definite sequence of metal and nonmetal.

By a little manipulation the teacher rearranges the elements for them about as follows:

H	He		Li	Be	B		C	N	O	F
	Ne		Na	Mg	Al		Si	P	S	Cl
	A		K	Ca	etc.					

Here we can introduce a bit of history telling the class that the first complete arrangement of the elements in accordance with this periodicity was made by two men: Mendelejeff a Russian, and Lothar Meyer a German, both publishing their results about the year 1869. This was many years before helium and argon were discovered. From Mendelejeff's arrangement we still have the following designations by groups:

Group	I	II	III	IV	V	VI	VII
Series 1	Li	Be	B	C	N	O	F
Series 2	Na	Mg	Al	Si	P	S	Cl

The remarkable thing about this is that sodium is very much like lithium, magnesium is like beryllium, aluminum is like boron and so on down the series. In other words: having simply arranged the elements *in the order of their atomic weights* we find that a certain regular repetition of properties appears so that the elements that occur in the vertical group columns are very closely related. So fundamental is this relation that on the strength of it Mendelejeff was able to foretell the discovery of certain elements; moreover, having been discovered they would be found to have such and such properties. He predicted three such elements and lived to see them all discovered and found to tally with his predictions in a marvelous way.

This is far more interesting for boys and girls than the fact that oxygen was first prepared in 1771 by Scheele or that sodium was first liberated by Sir Humphrey Davy in 1807. Aside from having shown the class one of the most wonderful of all natural phenomena, you have laid the foundation for teaching them in a simple, logical and impressive way the fundamental chemical laws and relationships.[1]

What Next?

We are now ready to begin the study of chemistry. The class has already noted the antithetical position of metals and nonmetals. It is an easy matter to lead them to understand, from facts they already know, that metals are positive while nonmetals are negative. Could anything be more natural? The two poles of a magnet are positive and negative; the series is

like a great magnet, positive at the left end and negative at the right. By means of the following diagram the gradation of positive and negative properties may be graphically represented:

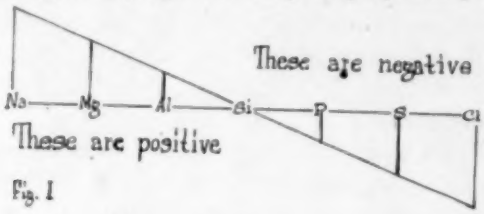


FIG. I.

From this it appears that properties vary gradually and that at the center of the series we have a zone of neutrality—just like a magnet.

It was mentioned a ways back that it would be desirable to give the study a chemical setting as early as possible. No doubt a great many think that we have gone far enough by this time. But we are going further. And the things that will now be mentioned are none too difficult, drawing largly on the fund of every day knowledge the pupils have when they enter the chemistry class.

Giving the Study the Chemical Atmosphere.

With the foundations now laid it is easy to point out that metals form bases and nonmetals form acids. The average alert child knows about acids and bases, although it is necessary for the teacher to reduce the science of it to the common terms of their every day knowledge. They know ammonia, lye, soda, and they know vinegar, sulphuric acid and muriatic acid. A good many of them know that mother mixes sour milk with soda in making soda biscuits. You show them that one of these groups turns litmus blue while the other turns it red; also that when a member of the "red" group is mixed with a member of the "blue" group, they lose all power to affect litmus paper.

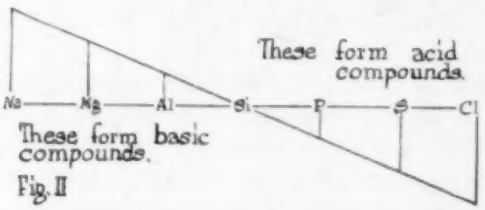


FIG. II.

Now they will grasp with avidity the fact that the "blue" division comes from the left of a series while then, of course, the "red" must come from the other end. The average child will draw the conclusion for himself that acids neutralize bases—a principle so universal as to be of use every day of the school year and for the rest of their lives. Another chart will help to enforce these facts:

The acid and basic "abilities" of the elements may be designated roughly as proportional to the lengths of the vertical lines associatd with the elements. Summarizing the characteristics so far enumerated in one graph we would have the following:

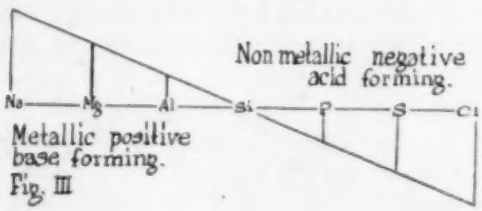


FIG. III.

How Elements Combine.

The class is now ready to tell you what elements will combine and with what degree of affinity. The most positive will naturally combine most actively with the most strongly negative to form the most stable compounds. The affinity elements have for each other is fairly represented by the degree of positive or negative as shown in the graphs. The pupils are now in a position to write out a large number of combinations that will take place and estimate to a considerable degree of certainty the stability of the compounds formed.

One great advantage at this point is the opportunity you have of letting the pupils do a little original work. It is original as far as they are concerned. Make them write out all the different combinations they think will form of the elements in the first and second series, using the symbols, thus: NaCl, NaS, NaP, NaO, NaF, etc. Let them now turn to the text book to see whether such combinations actually are given.

So far you have not mentioned to them the idea of valence nor have you used a single formula with a subscript in it. They come back pleased to have found the text mentioning compounds of sodium with chlorine, sodium with sulphur, sodium with oxygen and sodium with phosphorus, but there is something

that bothers them. In the text they find Na_2O, Na_2P, Na_2S, etc. whereas they had NaO, NaP, NaS, etc.

Teaching of Valence a Natural Operation.

They have made another discovery and have *compelled you to teach them about valence.* That is, pedagogically, something quite different from your *compelling them to learn about valence.* It is in a nut shell the difference between the "pouring in" and the "drawing out" process of teaching. Besides they have given you an excellent starting point. They have written: NaCl, NaS, NaP. The book has it NaCl, Na_2S, Na_2P. What more do you need? Chlorine unites with one sodium, sulphur with two and phosphorus with three. All atoms do not unite atom for atom but have different combining capacities. That is what is meant by valence.

Give them this problem. Try to find in the text several elements that unite with chlorine unit for unit. They will report back HCl, KCl, AgCl, etc. Then look up examples of metals holding two chlorines. They find $CaCl_2$, $MgCl_2$, $CuCl_2$, etc. By a little leading they may find $AlCl_3$, and even CCl_4 and $SiCl_4$. Refer back to our table of the first two series and let us make a summary:

Na	Group I	Holds One	Chlorine
Mg	Group II	Holds Two	Chlorines
Al	Group III	Holds Three	Chlorines
Si	Group IV	Holds Four	Chlorines
P	Group V	Holds Five	Chlorines
S	Group VI	Holds Six	Fluorines

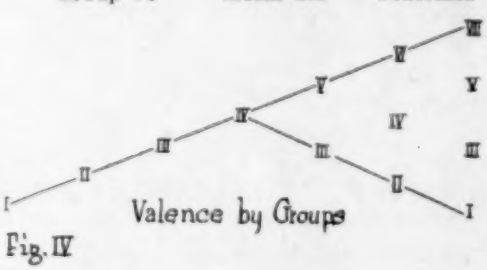


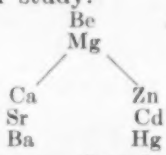
FIG. IV. VALENCE BY GROUPS.

Here one may anticipate a little on their knowledge, or by taking time to introduce oxygen compounds one may show that Group V has valences of three and five; Group VI has valences of two, four, and six; and finally that Group VII has valences of one, three, five, and seven. This may be graphically represented as follows:

Another season of drill in writing the binaries that can be formed from the first and second series will result in fastening indelibly in their minds the idea of valence. Structural formulas must be used by all means. The graphic method of representation carries with it definite proof that they understand what they are doing; the other may be merely the repetition of a rule by rote.

The "Long Series" Arrangement

The writer has never fancied the Mendelejeffian grouping as given in the usual text book table or the common wall charts. it is confusing to the pupil, as no doubt to the older person sometimes, to have Be, Mg, Ca, Sr, Ba, Zn, Cd, Hg, all in one column and group. There is no doubt but that such grouping effectively defeats the advantages that might otherwise be derived from the System. The mere fact that from Ca and Zn down the group is subdivided into sub group A and sub group B, the former hugging the left hand edge and the latter the right hand edge of the space between the two lines called Group II does not help a great deal. A number of texts arrange the group in this way when they take it up for study.



and that helps some. But even that does not explain.

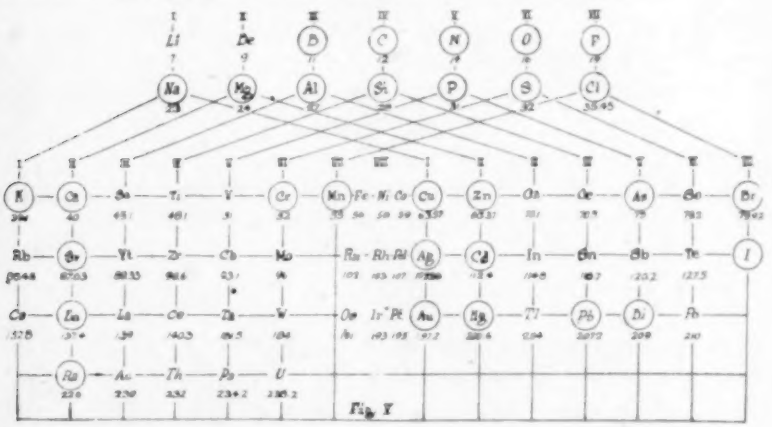


FIG. V.

The following Periodic Table makes the reason for the "A" and "B" subgrouping clear and serves to clarify a lot of questions that must come up later. (See Figure V.)

The long series from potassium to bromine is an entirely different proposition from the doubled-upon-itself two-short-series arrangement with copper coming under potassium, zinc under calcium, etc. Copper *does not belong* under potassium and certainly manganese should never keep company with bromine. At the extremes of this long series we find the same clear cut and definite properties that we find at the ends of the two short series above. In fact sodium and potassium are enough alike to be twins, as are also chlorine and bromine. But here the sharp relationships also end. You cannot say that calcium and zinc are very much alike. In going from potassium to manganese we pass through the same cycle of changes that we go through in the sodium series but the positive and metallic properties persist much farther to the right—so much so that even chromium and manganese are both distinctly matallic. But they are just as definitely nonmetallic forming acid derivatives of very stable properties. In like manner we find in the second half that acid properties show up very early. From zinc on towards the right acid properties rapidly increase while chemical metallic properties decrease finally disappearing altogether with selenium. A picture of this rather complicated influence of position may be derived from the following graph:

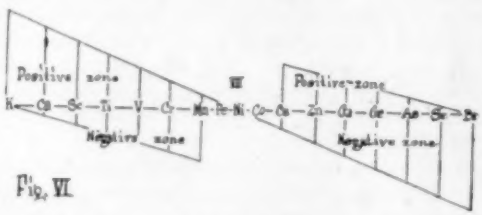


FIG. VI.

One can understand, now, why chromium, manganese, copper, gold, and mercury show a wobbliness with regard to valence. They belong in the zone of dual properties, where acid and basic, nonmetallic and metallic properties, so to speak, strive for supremacy. It is most natural that where elements have to divide properties with those of adjoining groups—live a double life—there should also be a division in the matter of valence. How literally this is the case is well illustrated by chromium and manganese. Chromium has valances of two and six in perfect accord with its group requirements but being situated between two odd valence groups it is not unexpected to find it

showing a valence of three also. Manganese on the other hand has valances of three and seven in accordance with its group but dips into Group VI for a valence of two and six. It is, therefore, not an inconsistency on the part of these two elements to show a mixture of odd and even valences; rather if they did not do it it would be inconsistent with their position. They are perfectly normal and behave in perfect accord with their position.

Daily use should be made of the periodic table shown in Figure V. The elements usually included in a year of high school study are enclosed in circles. This table alone gives a true perspective and the correct relationships between the elements. The writer has used it as a basis of study of first year chemistry for more than twenty years with uniformly good results. In this way first year chemistry becomes a unified and organized whole instead of "a jumble of disconnected facts and figures."

NOTABLE INVESTIGATIONS IN PHYSICS AT THE UNIVERSITY OF CHICAGO

Among the notable investigations in physics at the University of Chicago, according to the forthcoming *University Record*, is Professor Albert A. Michelson's redetermination of the velocity of light. Because of the clearness of the air in California, Professor Michelson is making the actual measurements in the vicinity of Mount Wilson Observatory. Light travels at a speed of 186,000 miles per second, and the difficulties of the experiment may be surmised when it is stated that the plan is to determine the comparatively short time taken by the light to travel over a measured distance of twenty miles and back to an accuracy of one part in three hundred thousand.

This is the second of the three great problems which Professor Michelson has set himself in the last few years, the first, the measurement of the diameter of a star, a feat equivalent to the measurement of a penny at a distance of 1,000 miles, having been accomplished.

The third problem, the effect of the earth's rotation on the velocity of light, which he is conducting in collaboration with Professor Henry G. Gale, is of great importance as a test of the ideas involved in the theory of relativity.

The object of this experiment is to ascertain whether a beam of light, traveling in a closed circuit on the earth's surface, experiences a drag on account of the earth's rotation. Two beams of light travel in opposite directions around a square a quarter of a mile on each side and meet again at their common source. On account of the earth's rotation, one beam will travel a distance slightly greater than that traveled by the other.

The difference in the two mile paths amounts to only about one hundred-thousandth part of an inch; yet preliminary experiments on a small scale have justified the belief that it will be possible to measure this difference to the one five-millionth part of an inch, and preparations for the final experiments are now in progress.

LABORATORY METHODS IN NATURAL SCIENCE TEACHING. I.

HARRY A. CUNNINGHAM,

The University of Kansas.

Does the individual experience of a pupil in laboratory work pay for the extra time and trouble, or will as good results be secured more economically from the lecture demonstration method, or will better results be achieved by individual laboratory work under some conditions and by the lecture demonstration method under other conditions? This is one of the few problems in science pedagogy upon which we are getting some objective evidence. The writer began studying this problem in 1919, and completed the first study in 1920[1]. Since that time at least two other excellent studies have been published dealing with the same problem.[2] In the meantime, I have repeated the study a second time. In each study I took into consideration both immediate results and retention.

In the present article, I shall deal with the groups selected for study; the experiments used in each case; the technique of giving the experiments; the methods of scoring; tabulating results; the presentation of immediate results; and the interpretation of these results. The presentation of results bearing upon retention; the comparison of these with the results obtained immediately after giving the experiments; the comparison of the performance of the dull and bright pupils under the two methods; and the raising of some pertinent questions relative to the explanation of the results obtained in these two studies will be reserved for a second article. One of the first problems in each study was to get two groups that would be comparable from the standpoint of ability.

In each case this was done by giving the Chicago Group Intelligence Test and by taking into consideration the school grades made by the students thus far in their high school course. In the first study it was possible to get the two classes practically balanced. Because of conflicting programs, it was not possible to balance one class against the other in the second study so individuals in the two classes were paired off on the

[1]Cunningham, Harry A. Individual Laboratory Work Vs. Lecture Demonstration in High School Science, Master's Thesis, University of Chicago. (Unpublished) 1920.
Cunningham, Harry A. Individual Laboratory Work Vs. Lecture Demonstration, University of Illinois Bulletin, 17:104-107, Dec. 6, 1920.

[2]Kiebler, E. W. & Woody, C.—Individual Laboratory Work Versus Demonstration in Teaching Physics, Journal of Educational Research, 7:50-58, Jan. 1923.
Cooprider, J. L.—Oral Vs. Written Instruction and Demonstration Vs. Individual Work In High School Science. School Science and Mathematics 22:838-844, Dec., 1922.
Cooprider, J. L. Laboratory Methods in High School Science. School Science and Mathematics 23:523—530, June, 1923.

basis of our findings in the Intelligence Test and school grades, so that we had a group of ten in one class balanced against a group of ten in the other and it is the results from these two groups that are considered in the second study. In each study the students were sophomores in high school botany.

Our next problem was to find experiments that could be given either as individual laboratory work or as lecture demonstration. Not all of the experiments used in these studies were of a botanical nature. Thirteen experiments were used in the first study and twelve in the second. Four experiments used in the first study were dropped from the list used in the second and three new experiments were introduced into the second study. The exercises might well be divided into three general classes: (1) those in which we are trying to clarify the child's concepts and give him new concepts through observation but in which no problem arises and no reasoning to conclusions is necessary; (2) those which give rise to a problem the explanation of which depends upon knowledge which the pupil does not possess and which is furnished him; and (3) those exercises in which the student must not only observe but must reason to nis correct conclusions unaided. Mimeographed directions were made for each study.

Each study was given to one section as a lecture demonstration and to the other as individual laboratory work. Thus, if class A did Experiment No. 1 as a lecture demonstration. it would do Experiment No. 2 as individual laboratory work. In individual laboratory work, the students were given the mimeographed directions and apparatus for the experiment. No further help was given. In lecture demonstration, the mimeographed directions were followed verbatim by the instructor. This made certain that the teacher did not exert any more influence under one method than under the other. The same apparatus was used in demonstration except in some cases it was larger. In the experiment entitled "Temperature Changes when Substances Dissolve" the students getting the work as a lecture demonstration were given the readings of a thermometer while the individual workers determined the change in temperature by feeling or temperature sense. Thus, except in the instance cited above, the method was the only thing that varied in the two studies.

Each exercise, except those in which no reasoning was necessary, was written up under three heads: (1) "what was done";

(2) "what happened"; and (3) an "explanation of why it happened." On ten exercises in the first study and eleven in the second, each student was timed from the time he began the exercise until his paper was ready to be handed to the instructor and the time, in minutes, required to complete the work was marked on every paper.

In scoring, a list of all the different points made by all the students under the three divisions; "what was done," "what happened," and "why it happened," was made and each individual student was scored in each of the three divisions and upon the experiment as a whole, on the basis of this list. These point scores were turned into per cent by dividing the points made in any division by the possible number of points that might have been made. For example, if, in any experiment, the total number of different points made by all the students in the "what was done" division was twelve; and any one individual student made six points, he made fifty per cent of the total number of points under that division. The total score on any experiment was originally figured in two ways. One total score was found by taking the sum of the points made under the "what was done," "what happened," and "explanation of why it happened," divisions and dividing this sum by the total number of possible points. The other total score was found by adding the score in per cent made under each these three divisions and dividing by three. This last method gives the scores under each of the three divisions equal weight in making up the final or total score. The relative results were approximately the same under the two methods of calculation. The results obtained by dividing the sum of the three scores in per cent by three will be used in this report to indicate the total score.

Turning to a brief consideration of results, we may note, in the first place the time taken by the two methods. In one exercise, "Temperature Changes when Substances Dissolve," the individual workers made better time in each study. This was due to the different methods of making the observations in this exercise. In the second study the individual workers also made better time on the exercise entitled "Convection Currents." This is one of the tests that Dr. Otis Caldwell used in the Gary Survey. From the point of view of economy of time, the results favor the lecture demonstration method. This advantage for the lecture demonstration method is not

so emphatic as some of the other studies of this problem indicate. In the first study an exercise was done in 12 minutes less time by the lecture demonstration method. In the second study this difference was reduced to 2.4 minutes. From these results, we may conclude that laboratory work may be done in less time by the lecture demonstration method but that this saving of time may not be enough to be of much consequence.

Let us now summarize briefly the final scores as indicated in Tables I and II and by Graphs 1 and 2. In addition, I shall mention briefly some of the things that come from a more careful study of individual cases.

Under the "what was done" division, we have the following conclusions. (1) The individual workers did not take very careful note of what was done in experiments whose methods of procedure were too common to draw their attention sufficiently to enable them to fix each step of the procedure in mind. This inference seems to be warranted by a study of the results under this division in the experiment testing for fats and oils. Two experiments immediately preceding this one were food tests and employed the same general type of procedure. In both studies the results of the test for Fats and Oils were very low for the individual workers. (2) In both studies, the lecture demonstration method gave very much better results for the experiment entitled, "Temperature Changes when Substances Dissolve." In this experiment, larger apparatus was used for the demonstration and the temperatures were taken with a thermometer. In individual work the changes in temperature were noted by holding the test tube in the hand. (3) In the first study, the mean of the total scores for work done by the lecture demonstration was 5% higher than for individual laboratory work. In the second study, Lecture demonstration was 7.2% higher. (4) On the whole, the immediate results were in favor of the lecture demonstration method in this division.

Under the "what happened" division, we note the following points. (1) Observation is the principal mental process employed in this division. (2) If the exact results of an experiment are difficult to obtain, such as the color tests for food, the individual workers are likely to make a lower score because many of the students will not get the right results. (3) One experiment was included in each study in which our main object was to clarify the child's concepts or give him new concepts

Table I. Summary of Results of First Study. Comparison of Scores under each Division, of Total Scores, and of Average Time.

	What was Done		What Happened		Explanation		Totals		Time	
Exercise	Score in %		Score in %		Score in %		Score in %		Time in minutes.	
No.	Dem.	Ind.	Dem.	Ind.	Dem.	Ind.	Dem.	Ind.	Dem.	Ind.
1	97	78.5	95	87.2	40.3	32	77.4	65.9	32.2	65
2	71.2	78.6	98.7	87.5	64.6	56.7	78.2	74.3	33.4	36.9
3	88	64	100	94	49	61	79	73	21	28.2
4	81.5	80	71.8	83.3	36.5	31.3	63.3	64.9	27.3	35.1
5	86.4	85.4	90.9	66.7	44.4	26.9	73.9	59.7	44.2	59.3
6	81.5	72.6	52.8	58.9	41.7	32.5	58.7	54.7	.....	.....
7	100	83.3	100	95.8	58.9	51.4	86.3	76.8	39.3	27.8
8	64.7	89.4	61.4	51.9	48.5	29.5	58.2	56.9	21.5	45.5
9	90	89.2	100	100	42.9	38.5	77.6	75.9	31.4	48
10	98.5	98.3	100	100	57.7	40.3	85.4	79.5	30.3	41.5
11	84.6	70.8	38.5	36.7	28.2	19.4	50.4	42.3	.....	.....
12	91.7	79	100	100	38.3	43	76.7	74	.....	.....
Av.	86+	81−	84+	80+	46−	38+	72	66+	31+	43

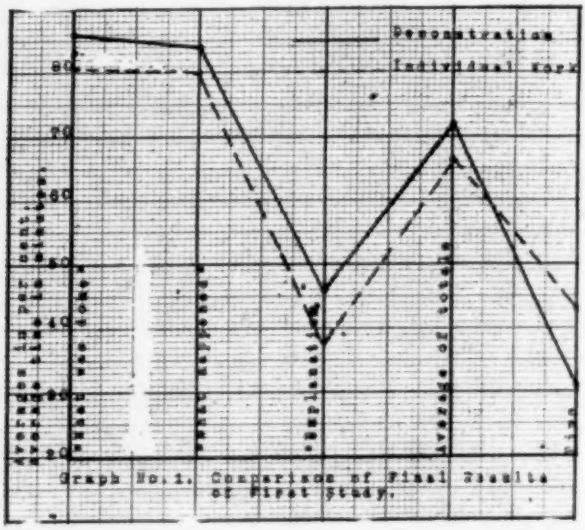
Table II. Summary of Results of Second Study. Comparison of Scores under each Division, of Total Scores, and of Average Time.

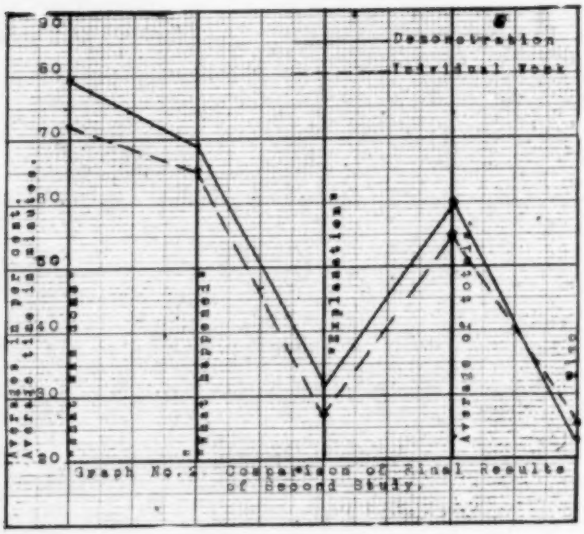
	What was Done		What Happened		Explanation		Totals		Time	
Exercise	Score in %		Score in %		Score in %		Score in %		Time in minutes	
No.	Dem.	Ind.	Dem.	Ind.	Dem.	Ind.	Dem.	Ind.	Dem.	Ind.
1	94.6	83.8	63.6	67	18.5	23.3	58.9	58	24.2	42.8
2	90.1	75.7	92.5	70	46	40	76.2	61.9	25.8	28.3
3	96.3	57	98.3	91.6	41.2	31.1	78.6	59.9	21.3	31.6
4	88.8	94.3	80.2	86.8	40	18	69.7	66.4	24.2	26.4
5	81.2	73.3	90.1	90	36.7	35	69.4	66.1	48.6	49.7
6	72.1	83	49.4	44.2	60.0	31.1	60.7	52.8	.....	.....
7	87.5	50	55	70	26	42	56.2	54	29.9	21.0
8	68.3	64	40.5	46.2	31.9	18.5	46.9	42.9	16.6	18.9
9	60.3	80.7	77.5	66.7	9.4	18.9	49.1	55.4	11.3	17
10	64.8	63.4	66.7	50	30.6	15	54.1	42.8	4.6	6.3
11	71.6	71.4	48	42	11.4	28.5	43.7	47.3	23.5	12.3
Av.	79.6	72.4	69.3	65.9	32	27.4	60.3	55.2	23	25.4

through observation but in which no problem arose and no reasoning to conclusions was necessary. The study of simple and compound leaves was used for this type of experiment in each study. The different types of simple and compound leaves were provided and attention was called to the characteristics of each type. The test was a written description of the characteristics of each type. The results of this experiment are not included in Tables I and II nor in Graphs I and II but are given in Table III.

Table III. Simple and Compound Leaves.

	Mean Score		Mean Time in Minutes	
Number of Study	Dem.	Ind.	Dem.	Ind.
First	40	42.9	21.9	33.5
Second	40.6	43.2	8.9	17
Mean	40.3	43+	15.4	25+





From Table III we see that the individual laboratory method gave better results each time for this type of study. (4) From Tables I and II, we see that the mean totals give the lecture demonstration an advantage of 4% in the first study and 3.4% in the second study.

In the "explanation" division, results from these two studies indicate the following. (1) All the results in this division were comparatively low; indicating that we are failing to give the proper training in scientific thinking. (2) As the complexity of the apparatus and the difficulty of the method of procedure increases, less and less valuable results are secured in the explanation through individual work. This may be true when high interest is exhibited in doing the experiment, indicating that the student's interest is in the manipulation, which is a primary instinct, rather than in the problem. (3) The mean scores under this division give the lecture demonstration method an advantage of 8% in the first study and 4.6% in the second study.

In making a summary study of graphs Nos. 1 and 2, we observe the following facts: (1) the graphs representing the summaries of the two studies are very similar in form; (2) the results are low in each study for the "explanation division," (3) the difference in time was much reduced in the second study; (4) the general results are in favor of the lecture demonstration method.

In conclusion let us keep in mind the following points. (1) The general results reported in this article do not always hold in individual cases. There is not space in this article to take up an extensive consideration of individual cases, but it is in the study of individual cases that most real value may be obtained from a study of this kind. (2) These data are based on performance immediately after the performance of the experiment. (3) It is not safe to make sweeping generalizations as to best laboratory methods from these data. All we can say is that these are the results from these two studies. (4) The following questions are raised for further consideration. Under which method will more be retained for a considerable length of time? Is the same method equally good for the bright and slow pupil? Just what are the real explanations underlying the results of these two studies? How should we proceed in the further study of this problem? In another article we shall take up these questions and present some data bearing upon them.

MATHEMATICS IN THE SENIOR HIGH SCHOOL.

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While the subject of this paper is the reorganization of the mathematics courses of the senior high school and my primary purpose is to make suggestions regarding those courses, I have found it necessary to devote the greater part of my time to the preceding courses of the elementary and junior high schools. For, the suggestions I shall make for changes in the courses of the senior high school are based upon the assumption that changes in the junior high school courses require them, or that principles which are effecting a re-organization of the junior high school course are equally applicable to that of the senior high school. It seems to me that both these conditions exist—that there have already started sufficient changes in the course in grades 1 to 9 inclusive to make radical changes of the course in grades 10 to 12 not only advisable but necessary; and that the same principles which have brought about the changes in the lower grades apply with equal force to the upper. What has been the trend of these changes in the elementary and junior high school courses and what are the principles upon which they are based?

In my judgment the most marked change, perhaps the one which has been the cause of most of the others, is the change from the logical to the psychological arrangement of subject-matter. To those of you who have been interested only in the teaching of college or of high school mathematics, this may seem a distinction without a difference. The logical arrangement seems necessarily the psychological one. How *could* one study fractions before factoring in algebra, or be taught calculus before trigonometry and analytics? All of which shows that the psychological organization, which has for the past thirty years been making over the mathematics course of the first six grades, has made little impression upon the courses of high schools and colleges. Forty years ago the arithmetic of the grades was arranged logically. In my first arithmetic lesson I learned that "arithmetic is the science of numbers," that "a number is a unit or a collection of units," that "notation is the art of writing numbers and numeration the art of reading numbers." Then I was taught to read and to write numbers from one to decillions. When we had *finished* notation we *began* addition, first defining addition, then learning the supposedly new fact

that 1 and 1 are 2. Thoroughness was the watchword. Each topic was thoroughly finished before the next was begun. In short, arithmetic was taught to children about as algebra, geometry, and calculus are now taught.

The content of elementary arithmetic has been re-organized. To some it seems entirely without organization. If you ask me where, in our elementary training school, we teach common fractions, I must say that the pupil begins it before he enters school and continues it throughout. When does he learn division of fractions? Before he leaves the third grade he can tell how many half dollars there are in two and one-half dollars, though he will sometimes make a mistake in dividing $2\frac{1}{2}$ by $\frac{1}{2}$ in the eighth grade. And yet the work in division of fractions is not without organization. In the fifth grade the pupil organizes his experience in dividing fractions, reaches some generalizations, and makes and practices the rule for dividing by a fraction. But then his work in division of fractions is just well begun. He must still have experience in using his rule under more and more complicated conditions and must have continued practice to develop mechanical skill in the process. And so, throughout the arithmetic course of the grades, the child begins with all those number experiences which he can connect with his past experiences, no matter what topic they come under. Before coming to school he has had experience in counting, adding, subtracting, and with fractions, rectangles, inches, pints. These experiences are repeated and enlarged. After the *notions* of addition, subtraction, etc., have developed through experience, the *names* are given. Names and symbols *follow* meanings and ideas.

The arrangement of the arithmetic course, then, is based on this plan: First, an extended experience with concrete number situations of whatever sort the child can connect with his past experience, and with little regard to topical arrangement; second a use of the symbols connected with these number notions and processes; third, an organization of these notions and processes as topics; fourth, extended drill to mechanize the use of the symbols in the processes; fifth, a still more extended experience in problem solving requiring the use of the skill developed.

About six years ago in the Training School of the Eastern Illinois State Teachers College we began an experiment in reorganizing the mathematics of the 7th, 8th, and 9th years on the basis just outlined. The 7th year's work was to contain,

first, continued application of all processes and generalizations of the first six grades. That is, the pupil was to extend his knowledge of and skill in the processes with integers, with common fractions, and with decimal fractions, though these topics had been finished in the fifth or sixth grades in the sense that the pupil had there learned to divide any two common fractions or any two decimal fractions. The 7th year's work was to contain, second, an extension of his experience to new material which he could connect with the old. This new material might come from the field of algebra which the pupil had probably touched not at all, from the field of geometry which he had begun to experience as early as the first grade, or from parts of the arithmetic which he had been unable to assimilate earlier. In selecting this new material the really important questions were, "Is it worth while?" and "Can the pupil assimilate it?" Should the most elementary facts of geometry be taught in the 7th grade? Yes, many of them, unless they have already been taught in the lower grades, in which case the experience that the child has should be built upon. In tenth year geometry we still teach a pupil that the area of a rectangle is the product of its base and altitude, though he was taught that fact just as well in the second or third grade.

The 7th grade course should include, third, the general treatment of certain topics with which the pupils have already had considerable experience but have not organized or generalized. This would include percentage and certain of its applications, as, interest or profit and loss. And the 7th year's work should include, fourth, extended applications of the use of common and decimal fractions involving more complicated number relations than could be introduced when these topics were treated generally.

We began our 7th grade work, then, with the solution of problems somewhat more complicated than those of the lower grades but involving no new notions or processes. The solution and classification of these problems led to certain generalizations. Many of them required the finding the area of a rectangle. The rule for finding the area of a rectangle was stated. The abbreviated form $A = ab$ was easily learned and its connection with the rule made by the pupil. Other rules were involved in other problems. These rules were stated by pupils and by them translated into formulas. The evolution of these formulas and their use in solving problems arose naturally while the class was

continuing the study of percentage, interest, and the problems arising in that study. And so the pupils had their first experiences with algebra. To them it was no more algebra than was the introduction of the per cent symbol when the new notion made the new symbol necessary. They had arrived at the notion of a general number, the base of *any* rectangle, and they needed a new symbol to represent it. The notion came before the symbol. Was that true of *your* notion of general number? It certainly was not of mine.

Notions of the geometric figures and their relations are so much simpler than those of general number that the child begins them much earlier without teaching. With it he grasps them very readily, indeed, and it seems to me that many more of the geometric forms and facts than we now teach should be presented *before* the 7th grade. We are extending our work in that direction, but *in* the 7th grade we found it possible to teach most of the forms and many of the facts of geometry on the topical plan. The whole of the 7th grade work, then, consisted of arithmetic, algebra, and geometry. The arithmetic consisted (1) of extension of problems and practice of topics completed in lower grades, and the completion of a few other topics. The algebra consisted of the incidental use of the formula and development of the notion of general number, with a minimum of topical treatment. The geometry consisted of an extension of the geometric notions and a topical treatment of the principal facts of geometry.

At the beginning of the 8th grade we found that the pupil had had enough experience with the algebraic symbols to be ready for a simple topical treatment—that is, he was ready to make some generalizations and acquire skill in applying them. He had often added $2a$ and $3a$ without stopping to define the process. He was now ready to make a rule for this process and to learn to apply the rule mechanically. And so the simpler fundamental processes were developed topically and drilled. Then this new skill was used in solving problems, in measuring geometric figures, in a topical study of ratio and proportion and its application to similar figures.

The work of the 9th year was continued on the same plan. The first half of the year's work was a topical treatment of elementary algebra, easily grasped because preceded by enough experience in using the algebraic symbols to make them meaningful. Throughout this work in algebra were numerous problems

involving past principles and skill in arithmetic, applications involving both new and old facts of geometry and much material leading directly to the elementary facts of trigonometry. Algebra through quadratics was completed in the first half of the 9th year with as good mastery of the mechanics as we have usually secured by devoting the whole of the 9th year to algebra and a much better grasp of the meaning and use of the symbols.

This gain of a half year in the 9th year algebra was made possible by the long exposure to the use of algebraic symbols throughout grades 7 and 8, and by the care taken to have the symbols mean something before they are used. Instead of telling the pupil that ab indicates that a is to be multiplied by b, then giving him expressions to be evaluated, and then concrete problems involving the processes, we first had the problem, to find the area of *any* rectangle. The pupil stated the rule in words, needed the symbols to abbreviate the rule, and needed to know how to indicate the multiplication of a by b. In the 9th year algebra which we wanted to begin with a topical treatment of signs of grouping, we first asked the class to bring in any number puzzles which they could find but could not explain. Among those brought in we found the following: "Take any number you wish; multiply it by 3; add 24; divide the result by three; subtract the original number. The result is 8."

By using n for the number chosen and indicating and then performing the operations required, the class readily saw how the result could be foretold, also the value of using the general number symbol. They immediately became interested in making such puzzles. Two samples of their work are as follows:

1. "Take the number of the day of the month on which you were born; add 2; multiply by 5; subtract 10; mutliply by 10; add the number of the month in which you were born; subtract 10; multiply by 10; multiply by 2; subtract 200; multiply by 5; add your age in years. Give me the result and I will tell you your age and the date of your birth." The result is $10000a$ plus $100b$ plus c; you are c years old. Your birthday comes on the ath day of the bth month. The indicated operations are:

$$\text{I} \parallel [(a+2)5-10]10+b-10 \parallel 10 \,.\, 2-\boxed{-200}\text{I}\ 5+c=10{,}000a+100b+c.$$

2. "Take the number 15; add the size of your shoe; add 10; multiply by 4; add 2; and give me the result. I can quickly tell the size of your shoe.

To get the size of the shoe from the result subtract 102 and

divide by 4. You can see it by this equation easily. $\{[(15+x+10) \cdot 4+2]-102\} \div 4=x$"

While we see no use whatever in such number puzzles except the entertainment they afford, we feel that the pupil who can make and interpret such statements is putting meaning into the symbols he uses. And the ability to use the symbols of algebra intelligently gives a value to the study which mechanical skill with the symbols alone does not. We believe, too, that such an exercise requiring the use of signs of grouping to indicate processes which the pupil needs to indicate, robs these signs of their terrors. In the first exercise the boy needed more signs of grouping than he knew, so he invented them. That boy had no trouble to interpret those signs.

The work of the second half of the 9th year was devoted almost entirely to demonstrative geometry. And here we violated several of the principles followed in the remainder of the course. In this half year little time was given to extending their knowledge and skill either in arithmetic or algebra. The course was built directly upon the experience with the notions and theorems of geometry learned in the 7th and 8th years. There was little reaching ahead into the elements of more advanced courses except trigonometry. In my mind demonstrative geometry is almost a thing apart from the other mathematics courses. Preceding it should be given an adequate experience with geometric notions and facts. Before the pupil begins the study of demonstrative geometry he should know the *meaning* of perpendicular, parallelogram, vertical angles, isosceles triangle, etc. He should also know that the diagonals of a parallelogram bisect each other, and most of the other theorems of geometry. The only new difficulty he should have to face is the proving of these facts which he has already tested in constructions and in other ways. By our plan the geometry of the 7th and 8th years has provided this foundation. We have also found it desirable to remove from the demonstrative geometry most of the so-called applied problems. Most of the applied problems of geometry we have given in the intuitive geometry of grades 7 and 8, in which the primary purpose is to learn the theorems and apply them. The purpose of this 9th year course is to teach pupils *to prove* theorems. The application of theorems to life's problems may increase the pupil's interest *in those problems*, but it has never seemed to me to increase his interest in proving the theorems. Almost the reverse is true. The pupil who has

felt the glow that comes from success in proving an original wants another original, not an applied problem. And the pupil who most enjoys the applied problems turns with regret to proofs which must be learned. This course in demonstrative geometry seems to me the one course in mathematics which must stand almost detached for a short period from the rest of mathematics.

Having given so large a part of the applied problems of geometry in grades 7 and 8 we found the time required for demonstrative geometry materially reduced. Our syllabus of theorems included all the fundamental theorems for which direct proofs are possible. We omitted the proofs of theorems involving inequalities and indirect methods of proof. The number of such theorems is small, too small to give a mastery of these methods of proof. We emphasized the analysis of theorems and, in a sense, made every theorem an original even when the complete proof was given immediately after the analysis. By the end of the 9th year we found the class to have as complete a mastery of direct demonstration of theorems in plane geometry as we formerly secured at the end of the 10th year. They have not proved as many theorems, nor have they learned as many methods of proof, but they have proved the more fundamental theorems and have mastered, rather than memorized proofs.

During the five or six years that we have been experimenting with the re-organization of the course for the 7th, 8th, and 9th years, a committee appointed by the Mathematical Association of America was at work upon the problem of reorganizing the mathematics courses of both the junior and senior high schools. The report of this committee, recently issued, recommends five plans for the organization of the junior high school course, all of which are distinct departures from the present course. In all of the five plans which they recommend, some arithmetic, algebra, geometry and trigonometry are recommended for grades 7, 8, and 9. The plans differ in the order of arrangement of these subjects, and also differ somewhat in the amount and kind of geometry offered. The five plans are as follows:

Plan A.
First year: Applications of arithmetic; intuitive geometry.
Second year: Algebra; applied arithmetic.
Third year: Algebra, trigonometry; demonstrative geometry.

Plan B.
First year: Same as A.
Second year: Algebra, intuitive geometry; trigonometry.
Third year: Applied arithmetic; algebra; trigonometry; demonstrative geometry.

Plan C.
First year: Applied arithmetic; intuitive geometry; algebra.
Second year: Algebra; intuitive geometry.
Third year: Trigonometry; demonstrative geometry; applied arithmetic.

Plan D.
First year: Applied arithmetic; intuitive geometry.
Second year: Intuitive geometry; algebra.
Third year: Algebra; trigonometry; applied arithmetic.

Plan E.
First year: Intuitive geometry; simple formulas; elementary principles of arithmetic.
Second year: Intuitive geometry; algebra; arithmetic.
Third year: Geometry; numerical trigonometry; arithmetic.

All of these plans provide for extended applications of arithmetic, an early introduction to algebra followed by the topical treatment, drill, and application; intuitive geometry; and the elements of trigonometry with applications. In three of the five plans demonstrative geometry is definitely recommended. In the fifth plan intuitive geometry is recommended for the 8th year and "geometry" for the 9th without specifying whether demonstrative or intuitive geometry is meant. Since the recommendations of the committee evidently indicate that demonstrative geometry is a possible and desirable part of the work of the 9th year, I shall base my suggestions for the work of the senior high school upon the assumption that the pupil has secured a fair mastery of the direct method of proving a theorem in geometry and can apply it to about fifty fundamental theorems as a minimum. And I shall assume a knowledge of the usual topics in algebra through quadratic equations, with less skill, perhaps, in some of the mechanical processes, but with more insight into the meaning and use of the symbols he uses. Based on such a course in mathematics for the junior high school as that suggested in Plan A of the committee, what shall be the course for the senior high school?

In my judgment the topical core of the 10th year's work should in the first half-year, be demonstrative geometry and, in the second half-year, a more completely organized algebra. The geometry of the first half-year should include theorems from both plane and solid geometry and the basis of organization should be the method of proof. In the 9th year the pupil has used only direct proofs and he has omitted some of the more difficult theorems which can be proved directly. He has proved no theorems of solid geometry. I see little reason for having kept the fields of plane and solid geometry so separate even

in the 9th year, and none at all for continuing to separate them in the 10th year. I would, then, begin the tenth year by extending the pupil's experience with the geometric solids, giving further training in visualization and in drawing the solids and planes in space. This I would follow by the simpler theorems of solid geometry which are proved directly. This would be followed by teaching the indirect method of proof, applying it to the theorems of both plane and solid geometry. By thus grouping the theorems requiring a particular method of proof, enough practice with that method can be given to make it stick. I think that most of us will agree that the principal difficulty in teaching the indirect proof has been that the pupil used it in theorems so scattered that the method never got fixed. This was certainly my trouble in attempting to teach the theorems involving variables and limits. I would now group those theorems, both those of plane and of solid geometry, and give them toward the close of the tenth year course.

While this course in demonstrative plane and solid geometry would constitute the core of the work of the first half of the tenth year, I would not lose sight of the other two phases; namely, the reaching back into all the past courses in mathematics and the reaching forward for a glimpse into the courses of the following years. There should be numerous problems applying arithmetic to plane and solid geometry. The problems should involve the use of both common and decimal fractions, per cents would not be uncommon, and problems connecting solid geometry and business arithmetic seem both desirable and possible. The pupil's use of algebra would be called into play and his knowledge of algebra extended by geometric construction and interpretation of algebraic results. Representing lines by a and b, the pupil should be taught to construct a plus b, a minus b, ab, $\sqrt{ab}$,—$b\pm\sqrt{ac}$, etc. He will also be taught to attack algebraically such problems as the dividing a line in extreme and mean ratio, will see that this involves the equation $\frac{a}{x}=\frac{x}{a-x}$ or $x^2+ax-a^2=0$, which he solves and finds that $x=\frac{-a}{2}\pm\frac{a\sqrt{5}}{2}$ When he constructs these solutions he discovers the method of construction given to him in most geometry tests. This demonstration he has usually memorized and often understood, but has seldom if ever had any part in discovering. All of us know the numerous exercises involving a use of algebra in

solving problems of both plane and solid geometry, but these have generally been omitted, for lack of time, either by the textbook makers or by the teachers. We have been teaching two or three theorems involving algebra in plane geometry, namely, "The square of the side of a triangle opposite an acute angle," etc. and the pupils have found them so difficult that they are often omitted. Why? Because the pupils have had algebra, have recovered (most of them), and are immune. If we were making use of algebra almost continuously in more and simpler exercises, these theorems would not be difficult.

Besides reaching back into the pupil's past course in mathematics and applying his arithmetic and algebra to geometry, we should reach forward, certainly into trigonometry, and possibly take a look toward analytics and calculus. During his junior high school course in connection with the theorems about similar triangles and the application of those theorems, the pupil learned the meaning of the trigonometric functions and how to use them in solving right triangles and in many applied problems. In the plane and solid geometry of the tenth year in connection with the regular polygons and elsewhere, he may be given many problems involving the use of trigonometry. And he can also prove many of the laws of trigonometry. It has always seemed to me rather foolish to have a year intervene between "The square of a side of a triangle opposite an acute angle, etc.," and the law of cosines.

The core of the work for the second half of the 10th year should be, in my judgment, a systematic, logically organized course in algebra. And it should have, as one of its primary purposes, the development of sufficient skill in algebraic processes to meet the needs of trigonometry and the elements of analytics and calculus. I would have this course begin at the beginning of algebra, not as if the pupil had had no previous knowledge of algebra, but as if he now had sufficient experience with it to need organization and transformation into skill. The course would be substantially the one now generally given in the 11th year as the third half-year's work in algebra. I would change this course only by having it reach back into arithmetic and geometry and forward into trigonometry and analytics. The problems given would revive the pupil's skill with both decimal and common fractions. Not all the equations solved would have small integral roots, simply checked. More problems connecting algebra and geometry would be used, this

time for the purpose of developing skill in algebra. To increase the pupil's skill in the transformation of equalities, the proof of many trigonometric identities would be used. Many of the elementary facts of analytic geometry would be introduced by extending a little the graphic algebra usually given.

The remainder of the senior high school course is—in my mind—only in outline which becomes more and more hazy for each half-year. I have only a few fairly definite suggestions for the work of the 11th and 12th years. The core of the work for the first half of the 11th year would be trigonometry. This would be built upon a considerable experience with the trigonometric functions from the 9th grade on. This longer exposure to the notions of trigonometry should make it possible to take up more difficult problems than are usually given in high school trigonometry. It seems to me desirable to teach the elementary notions of mechanics and to use trigonometry and the elementary notions of the calculus in their solution. In the last half of the 11th year I am inclined toward making the elements of analytics the core of the work. The 12th year I would divide between a more extended course in algebra and an elementary course in calculus.

In our experimental work with these courses our main purpose is their re-organization on what seems to us the psychological basis. To me this does not mean "mixed mathematics" in the sense of breaking down all lines between the subjects and topics. At any given time the teacher and pupils will know that a certain topic of algebra, or geometry, or trigonometry constitutes the core of the work; but this will not prevent introducing the notion of the trigonometric functions when studying the geometry of similar triangles, the use of the formula in percentage, and of per cents in trigonometry. The primary purpose of the reorganization is to maintain the abilities developed in previous courses and to give early the elementary notions and problems of courses to be developed logically later.

PENNSYLVANIA STATE COLLEGE ACTIVE IN REFORESTATION

The forestry extension department of the Pennsylvania State College will plant about 34 new demonstration areas this year, according to present plans. The work of reforestation or improving timberlands has already been carried into half the counties of the State. At 33 points on well-traveled public highways the college has established demonstration areas, so that the public may become acquainted with the results and possibilities of forestation work.

THE ORGANIZATION OF A SCIENCE CLUB[1].

RAYMOND LUSSENHOP, PRESIDENT 1922.

Bowen High School, Chicago, Ill.

The remarkable success of the Bowen Bird Boosters cannot be accounted for by the location of Bowen High School in the great Calumet district, where the students are accustomed to see smoke stacks instead of trees. To find the reasons for success, then, we must inspect the organization, the activities, and the policies of this science club.

Science teaches us accuracy, conciseness, and clearness. Why should its clubs not follow this trend? The purposes of this club are very plainly defined in the constitution, which states: "The objects for which this club is formed are: (1) to study birds; (2) to protect the birds; (3) to attract birds around our school, in our parks, and about our homes; (4) to subscribe for current bird literature and to support the Audubon Society both financially and with our influence."

"The officers of the club shall consist of a president, a vice-president, a secretary, and a treasurer." By an unwritten law, the president and treasurer are always boys; the vice-president and secretary are always girls. These officers are elected every spring. They must be members of the Zoology classes of that year and must be sophomores. The officers cannot be re-elected. This prevents a small group from getting and keeping control, a deadly mistake in any organization.

The membership is limited to those students who have taken or are taking bird study in the Zoology classes. At present the membership is 275. At the end of each year, all old members are dropped unless they retain their membership by the payment of their dues. For the first year the dues are 35 cents; for each year after the first, Juniors: 10 cents; Seniors: 5 cents. Seniors and Juniors taking Zoology are eligible for membership but not for holding office. Faculty members may be admitted to membership only on the recommendation of a student member of the club. The discussion and the vote on this prospective member must be held in secret, no member of the faculty remaining in the room while the students discuss or vote on such a motion. Faculty membership is only honorary, as the voting privilege is withheld. We have 13 at present.

Of course, the most important activities of such clubs are their meetings. During the fall term, the Bowen Bird Boosters hold their meetings once a month, during the spring term, once

every two weeks. The programs for these meetings are always posted a week in advance and are centered around a certain topic. For instance, a program will be centered around pigeons, or bird pests and their control; our game birds; migration, etc. At least two musical numbers are rendered but such numbers are always kept from being the most prominent part of the program. Every student taking part in the program must be a member of the club. This rule is inflexible.

Regular meetings are never allowed to become social gatherings; but an annual picnic held once every spring in some forest preserve, which can be reached by truck, is especially for fun. Our largest social affair, a fine program and dance, was given on our tenth anniversary. Even at this affair, attended by about 400 members, many belonging ten years back, the program was entirely a student affair. The constitution does permit prominent men who are interested in birds to appear on programs, as game wardens, museum workers, etc., men who are able to give interesting talks.

The policy kept in mind concerning programs is: (1) a program should never fail. If the program is made a farce, if the dignity of the occasion is forgotten for one moment, the program is a failure. It may amuse, it may even instruct, but its negative result is very serious, for each time a program falls through more students will lose interest and the club loyalty will lag; (2) all students scheduled for appearance must be present at the meeting and no excuses excepting those of sickness are accepted. In ten years we have had but two failures to appear (3) to give real information. In order to obtain the best results, all reports are prepared under the guidance of the faculty adviser. Students in the first two years of high school have not, as a rule, had much training in outlining material. The faculty adviser sees that each student understands clearly his subject and that he knows which points are most important. In this way, the students gain confidence and can appear before the club with poise and dignity. Another activity which deals directly with bird study is that of the bird identification lists. Three records are kept, the individual, the class, and the club. The individual record is kept by the student, on which he records all the birds he identifies on his bird hikes, or that he sees, on his way to school. Spaces on these lists must be filled out as to the date, the bird's name, whether single or in flocks,

[1]From Illinois State Academy of Science, Transactions Vol. 17.

place where seen, and what the bird is doing. The faculty adviser checks these lists from time to time, and corrects any mistakes. The class list is posted on a bulletin board and if a student has identified ten birds, a red star is placed after his name; if 25, a silver star; if 50, a gold; if 100, a blue bird. This arouses enthusiasm in each class. On the third record, which is furnished by the Illinois Audubon Society, the bird names are already printed with blank spaces in which the name and date of the first observer may be written. This arouses the keenest competition. These lists are of the most practical value in making the students familiar with our more common birds. For this work, the Reed bird guides are indispensible.

After careful analysis and consultation with some of our student members, I have come to the conclusion that the keystone of success of such a club does not rest so much in the organization nor activities but in the wisdom of the relation of the faculty adviser and the faculty members to the students. In the first contact that students have with our club adviser the policy is clearly shown. When the incoming members begin their election campaign, no hints or suggestions are thrown out about who would make good officers, so that the students would feel almost forced to elect the adviser's choice. Such a choice is left entirely to the students. Moreover, the faculty adviser promises to work cheerfully with their choice no matter if she does not approve entirely of the student put into the position. No requirement in the way of scholarship is demanded; just good, all-around fellows the students admire. And in the ten years, not a set of officers has failed. The students know who is who, and no year is going to see its officers disgrace the Bowen Bird Boosters. It is an honor to be elected to office and every fellow is determined to do his best if given that honor by fellow students.

The merits of the many forms of student government are still under discussion. It is plainly a fact, however, that when students are told that a club is theirs and theirs alone, they want that club to be the student's in fact and not only in theory. The wise faculty adviser must always remember that she is an adviser and not a president of that club. The officers should be confident of the teacher's ability and support. They should regard her as a friend when in office and as a teacher in the class room, relations which are very different. When high school students want their student organizations to be managed by

students, many teachers seem to misunderstand. Students do not want the faculty advisers to sit back and say, "All right, if you want to run your own organization we will have nothing to do with your affairs." Students simply mean that they want co-operation on both sides. The faculty adviser should look after affairs as to preparation and advice and the students should carry such affairs out in their own ways and methods. Teach principles, and let the students apply them.

If science teachers really wish to humanize and make science work more practical, what better means could be found than a science club? But it takes time; in the case of the Bowen Bird Boosters it has taken ten years to build up a set of policies and principles making co-operation secure. If the faculty advisers wish to manage the business, if they wish to appear on programs, and if they desire to be conspicuous for their work, they cannot make students believe it is a student's club. The adviser's praise must be the club's growth in strength and influence. If the adviser disregards personal prejudices and treats students as equals in the same club, and if the club is founded and run on principles of student democracy, success is bound to result.

Not a great deal of business is necessary in such an organization, but that which is, must be handled in a business-like way. Our secretary's book contains the record of every meeting and event, for the entire ten years. The treasurer's book, and the accounts for the same, are audited twice a year by the president and faculty adviser. These are open at any time for the inspection of the members. Develop some traditions to bind the successive years together. We have a standard pin; each year subscribes for the magazine "Bird Lore" for the next year; each year leaves a present for the laboratory. The ten years have built up a bird-bath fund of $75.00. This bath designed by a former president will be cast this summer and placed in our school yard.

PRESENCE OF LIVING ORGANISMS IN LAKE ICE[1].

SAMUEL EDDY,

James Miliken University.

The object of these experiments and observations was to determine what forms of life were existing in the ice of Lake Decatur. Lake Decatur is an artificial lake seven miles long

[1]From Illinois State Academy of Science Transaction, Vol. 17.

and one-half mile wide, created by damning the Sangamon river. The depth of the water varied from a few inches to forty feet. The periods at which the materials were collected were during zero weather when the lake was entirely frozen over. The thickness of the ice ranged from eight to twelve inches.

On January 7, two samples of ice and two samples of water from below the ice were collected. The ice was taken from the surface near the shore and from the center. Each sample was immediately placed in sterilized bottles containing sterilized hay infusion and plugged with cotton. The samples of water, at a temperature of one-half degree Centigrade, were taken from the holes from which the ice was cut. The samples were placed in similar bottles and under the same conditions. A sample of mud from near the shore was also treated in the same manner. In the cultures from the ice and hay infusions, observations were made January 23, January 28, and February 6. On all these dates various bacteria were common. The only other form of life observed was Chlamydomonas which was present in small numbers on January 23, but multiplied rapidly enough to be common on the other observation dates. In the cultures from the hay infusion, and lake water or mud examined under the same conditions on the same days, Chlamydomonas, Urosomas, Chilomonas, Coleps, Pleuronema, Stilonichia and many others unidentified protozoa were observed.

On January 25, two samples of ice, four of water and two of mud were collected and treated the same as those collected January 7. Nutrient agar was substituted for the hay infusion. Observations were made January 31 and February 7. The results were practically the same. Chlamydomonas and bacteria were the only forms of life in the ice cultures. Chlamydomonas, Leucophrys, Paramecium, Ameba, and other protozoa were common in the water and mud cultures.

On February 22, four samples of ice, and two of water were collected and treated the same as before. Three cultures of sterilized lake water and nutrient agar were made at the same time and subjected to the same conditions in order to determine if infection from the air could account for any of the resulting forms. Observations on all these cultures were made February 27 and March 4. In the ice cultures, Chlamydomonas and bacteria appeared. In the water cultures, Chlamydomonas, Pleuromonas, Ameba, and other protozoa were common. In the sterilized lake water culture used as an additional check,

no forms of life were present, indicating that the probability of the origin of any of these forms from the atmosphere was slight.

On February 7, four cultures of Chlamydomonas containing also Paramecium, were frozen from twelve to twenty-four hours and then thawed. The cultures were kept isolated and observed February 14. The only forms observed after thawing were Chlamydomonas and bacteria. These organisms were present in all four cultures. The Paramecium which were common before freezing never appeared after freezing and thawing.

In the eight samples of ice collected from Lake Decatur at three different dates, bacteria and Chlamydomonas seemed the only forms present. From the water just under the ice, many different protozoa were obtained. In all the cultures, except those of sterilized lake water, bacteria were observed, but were not regarded as of much significance as they easily withstand freezing and thawing. It seems that Chlamydomonas is the only form of protozoa in Lake Decatur able to survive freezing and thawing.

EYE SIGHT CONSERVATION.

Over half the workers in the United States engaged in building our motor cars lack normal vision, investigations by the Eye Sight Conservation Council of America reveal. Similar conditions, it is asserted, exist among millions employed in other enterprises.

Tests carried out by the Buick Motor Company at its plant in Flint, Mich., in co-operation with the Council, show, as reported by R. F. Thalner, the Safety Director of the Personal Service Department of the Company, that 56 per cent of the company's new employes have defective eyesight, the eyes of all having been examined when application for employment was made.

Working with the Council in its nationwide campaign of eye conservation, the Buick Company is testing the eyesight of each applicant for work, the results being recorded daily on the personal record cards of employes, who at this time total 24,451.

The situation at the Buick plant, following similar revelations at the Ford works in Detroit, and at other large industrial establishments, provide ample evidence that neglect by industry of the eyes of workers continues widespread according to the Council, which, in its report, just issued, says:

"The results of eyesight tests of the 3,513 applicants for employment with the Buick Company may be considered as a representative standard of measurement not only for the entire automobile industry but for the millions of persons engaged in other industrial pursuits in the United States. The persons examined at the Flint plant came from many different types of occupations seeking employment in the great variety of jobs to be had in a large plant manufacturing a highly complicated product."

The complete figures on the Buick Company's tests for four months show that only 194 or 5.5 per cent of this group of 3,513 had their vision corrected while 1,970 or 56.1 per cent were in need of correction. During the first month eye tests were made of 1,566 applicants for employment which revealed 56.8 per cent with defective vision. Of 892 applicants during the second month, the defective percentage was 56.9; of 188 during the third month, the percentage was 55.3, and of 767 during the fourth month, it was 54. The average for the four months disclosed that 56.1 per cent of the 3,513 applicants had poor eyesight.

"New employes of the Buick Company who have eye defects of a sufficient degree to handicap them are assisted in having their defective vision corrected. The company is looking after the eyes of its employes in other ways also. The Safety Department is carrying on a well organized accident prevention campaign. Definite regulations governing eye protection are embodied in safety rules which apply to the wearing of goggles. The management supplies goggles to workers occupying jobs which afford the slightest likelihood of eye injury.

"The number of eye accidents has been greatly reduced since 1921, when the goggle campaign was started. In 1920, thirteen persons were blinded in one eye; this number had been steadily reduced to five in 1921; to three in 1922, and to three in 1923. Provision is now made for placing in non-hazardous jobs those disabled through eye injuries."

Lighting is an essential factor of the Buick system of conservation, ninety-five per cent of the work in the plant being done by artificial illumination. Measurements are made in the various departments to determine whether the proper amount and distribution of light is provided.

Elaborate provision is made for the maintenance of the lighting system. Painting the ceiling and the upper part of the side walls white is an effective aid. These and kindred devices contribute vitally to the end sought.

The result of this system of prevention, it is said in the report of the Council, is increased production, "due to many incidental factors such as fewer accidents, less waste and spoilage of material, improved quality of workmanship and greater individual comfort and efficiency."

"The records," the Eye Sight Conservation Council's report discloses, "cover the examination of the eyes of 204,817 employes. It is regrettable that there are not more than 100 or 150 companies in the United States employing upwards of 1,000 persons which consider it essential to test the eyes of applicants for employment. Still fewer companies carry on this activity periodically for permanent employes."

The Council recently completed a national survey of conditions affecting the eyesight of industrial workers and school children, the findings being embodied in a report now being prepared for publication.

"The completion of this undertaking," the Council's report concludes, "has been made possible by the splendid co-operation of the many industrial executives, school authorities and state officials who have generously supplied information and who have in this way given assistance in promoting a wider knowledge of the importance of eye hygiene and care of the eyes."

ERRATUM.—On page 668 of the June issue of this journal, the book review on "Economics," second line, the word "contrite" should read "concrete."

CATCHING THE RABBIT IN OUR HIGH SCHOOL SCIENCE WORK.

By GEORGE N. THURSTON,
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Kilbourne, Ohio.

In a recent issue of the *Science News-Letter*, Dr. Slosson calls attention to the analogy between the procedure of the scientist and the old recipe which began "First catch your hare and then cut it in pieces." Dr. Slosson says the scientist "First catches the fact and then takes it apart."

With our eyes wide open to the dangers of following an analogy too far let us abandon ourselves to the pursuit for a little while and see if we can not bag some game for the teacher of high school science.

A recipe which begins with such specific details doubtless continues its careful instructions throughout. We wish we had a copy to enlighten our ignorance of the rest of the process. Of course there must be many ingredients besides the hare, and there must be a variety of conditions to be met. There must be seasoning and, there must be a proper cooking temperature, and this temperature must be maintained for a certain length of time before a product worthy of the gastronomic hardihood of those who eat such preparations could be achieved.

There were thus three stages at least,—catching, cutting, and cooking and there are some who say that there was a fourth stage, a pathological stage, especially for those with low D. Q.'s., (Digestive Quotients).

Now all scientists will admit that there is a *third* stage to scientific work. After the fact is caught and taken apart there is much concocting and cooking to be done,—much relationing of the facts and arranging the parts in their proper sequence. For it is a well known fact that from the time of Galileo to that of Einstein, from Archimedes to Steinmetz, from the inventor of the ox-cart to Henry Ford, facts have bobbed up before the scientist's guns without any regard for logical order. And then sometimes facts have been carved so crudely that it has even been necessary to put them back together and carve them over before they would fit the casserole. And there are facts which can not be carved at all.

For the sake of brevity, as well as for the sake of the consciences of us high school teachers, let us refrain from discussing the *fourth* stage.

Now the question is, what stage or stages of science are we dealing with in the high school. Is the young scientist a catcher, a carver, or a cooker? There is much evidence to show that he is first of all a "catcher," if we but give him a chance. He is out gunning for facts, for facts of experience. "What can I do with this?" "What will this do?", "How does it work?", or "What can I make out of this?", are the questions uppermost in his mind. Questions like these are at the foundation of such thriving business enterprises as the manufacture of engineering toys, chemical sets, amateur radio outfits and scout paraphernalia.

How much of the development of amateur radio is due to our science teaching in the high school? No., we can't claim much of the honor; they know most of the hookups before they reach our classes don't they? And they may never have heard of Maxwell or Hertz or know that there are electrons in their vacuum tubes. How do they do it? Why they went out gunning for facts, for experiences. Some of them they took apart, some of them they may have cooked, but for the most part they ate them raw. Yes, we may shudder at the process, we logically minded teachers, but we will have to admit that amateur radio developed to greater proportions in the hands of the boys and the engineers, than it would have done if we had been the middlemen dispensing the information in its beautifully logical sequence.

This is on the same principle that children can play "ring round the rosy" or "fox and geese" without knowing the ratio of the diameter of the circle to the circumference.

In pleading that our high school pupils may be given the opportunity of getting experiences in a wide field without over attention to the refinements of modern theory and method, or, to stick to our figure, without being required to do a maximum of cooking with a minimum of supplies in their larder, let us note that great scientists do not always take their facts apart and assign them to their proper dish immediately. Facts will keep fairly well. They are preserved more by enthusiasm than by refrigeration. Consider Michael Faraday. He was elated one time in a lecture by seeing that the magnetic needle was deflected by a current in the wire he was manipulating. Now he did not take that fact apart right away; at least not during that "laboratory period," as most of our students are expected to do, for we have a record of Gladstone's questioning later, "What of it Mr. Faraday, if the needle does move, of

what use is it?". And poor, stupid Michael did not know, for he had to retort, "O well, some day you may be able to tax it Mr. Gladstone." Now they say it took Michael Faraday ten days to make out of this what we have cooked up for our students to devour in one laboratory period. Priestly discovered "dephlogisticated air," and many facts concerning its behaviour; but he failed utterly to take these facts apart properly although Father Time spared his life for thirty years. Did his misinterpretation prevent him from enjoying the experiences, or detract from the value of the facts to Lavoisier or from the honor we give Priestly?

There is pleasure in hunting for facts just as there is pleasure in hunting rabbits. But there can be conditions which take the joy out of anything. Let us imagine this sort of procedure: A tutor takes his pupil out rabbit hunting. The region is alive with the little animals but the boy has never hunted before. Soon the tutor cautions the boy, "You just wait here a moment. son. Right ahead there is a rabbit that I have caught before. I have tied his tail to a stump and now standing at a little distance I will hold his head to the ground with this forked stick while you shoot." Wouldn't that be interesting sport! And then if the lad had to make a drawing of the arrangement, map the location, record the weight of the rabbit and the length of its ears in a notebook, how soon would little Algernon become a Daniel Boone?

Do you not see the analogy of this in the type of laboratory experiment we set before our pupils today? Pick up a manual and look. Are these not typical questions? "What is left in the test tube after the coal is heated? What are the uses of *Coke?*" "Multiply the numbers in Column H by the corresponding numbers in column K. Put the products in Column L. What do you discover?" Or this "Fasten a piece of charcoal to the end of a piece of picture wire. Heat the charcoal till it glows and then quickly thrust the wire into a bottle of the gas. *Why does the iron burn so brilliantly?*" This is a little better than another manual which says, "*You will be surprised to see the iron burn brilliantly.*" What a surprise party!

It is not necessary for us to lead our scientific facts and tie them down by all four feet. Experiments can be devised so that the facts pop out like rabbits out of a brush pile. When students actually do "catch" a fact for themselves their enthusiasm runs over. It is as new to them as magnetic induction

was to Faraday. It is enthusiasm of this kind that will lead them, just as it has led all scientists, into the next stages,—the taking apart and the logical cataloguing of the parts, the theory some call it. "Never teach a theory until you have created a mental necessity for it," said a well known teacher of college physics to his class. The educationists would revise this statement this way, "You *can't* teach a 'theory' until there is a mental necessity in the mind of the pupil for it."

Or to follow the analogy a little farther, we can put it this way: If the high school scientist is to be taught to carve and cook he must learn to do it on his own "catch." What if the meat is scorched in his little campfire rather than broiled in the accurately regulated oven of our electric range. He will enjoy the eating of it all the more.

This then is the breaking point of the analogy,—the eating. For any one can eat, whether he caught the rabbit or not. But the pupil who is to be nourished by the vitamines of science must himself catch the facts.

Endless futile discussions could easily follow from pressing our analogy too far, but the essential points of it may be summarized as follows:

1. In high school science, students must have fresh "meat."
2. They cannot digest the highly seasoned salads prepared, no matter how skillfully, by others. Ptomainic symptoms are the result of most attempts to do so.
3. In the beginning, at least, they must catch the facts themselves. This is scientific procedure. In no field of science will the research workers accept the findings of one of their number without abundant verification.

As an illustration of (3) notice the comments that are being made upon the work of Dr. Kammerrer of Vienna who is now touring this country lecturing on the results of his experiments which seem to show that acquired traits may be innerited. The gist of the comments is: *We will not accept this view until we find the same facts ourselves.*

Now, perhaps Dr. Kammerrer is a careful experimenter and a clear "rigorous" thinker. Perhaps he has discovered, actual facts and has given them the proper interpretation, nevertheless, until a sufficient number of scientists have made the same observations and checked up on the explanations and until they have analyzed Kammerrer's work into elements of experience familiar to them they will not accept his findings.

Numerous illustrations of this attitude can be given. This is the way of science. It always has been the way and always will be. *There can be no science without it.*

Demagogues, quacks, the superstitious and other feeble minded folk will accept unreservedly any dogmatic statement they wish to believe no matter what the authority. In this they are the direct antithesis of the scientist.

Into which of these two antithetic classes, then, will we consign our pupils if we ask them to accept *without* experience? And yet we do that very thing when *we* give copious instructions before *they* experiment; when we tell them what is going to happen before it happens, or when we tell what would happen if we would do so and so with such and such apparatus under normal conditions if such were obtainable at the time and place the supposed experiment transpired.

If we need any further confirmation of the psychological truth underlying this let's turn to Michael Faraday: "I was never able" says he, "to make a fact my own without seeing it. And the descriptions of the best works failed to convey to my mind such a knowledge of things as to allow myself to form a judgment upon them. If Grove or Wheatstone or Gassiott or any other told me a new fact, and wanted my opinion either of its value or the evidence it could give on any subject, I could never say anything until I had seen the fact . . . All the work had to be my own." Again we'll say poor, stupid Michael. What grade would he make in some of our science classes today?

What shall we do then with the little skeptic, who asks such questions as "How do they know there are germs?" Tell him as some teachers have been known to do, by their attitude at least, "If the author of this book says there are germs, there are germs. Don't you think he ought to know?", or shall we turn to the microscope and cultures? Or again some chap asks, "How do they know it is ninety three million miles to the sun?"; why not give him a scout manual and let him measure an inaccessible distance, such as the height of a tree or the width of a river? He is by nature a scientist and will put himself in that class if we but let him.

How often do we hear teachers justifying the teaching of this or that by the expression, "Well, I think they ought to know it." Especially is this statement often made of the so called theories —ready made solutions to problems that probably have never entered the students' head. We are not discussing here the

selection of material. Perhaps they ought to know it. But if they ought the psychology of the situation is the same as it was when the theory was developed. There were problems in Dalton's mind growing out of experiences. The atomic theory was his attempt to explain these experiences. It simplified his thinking. Something of the sort was necessary.

The teacher, then, who wishes to teach such things must found the teaching upon the *pupils'* experience. They can not learn it any other way.

I discovered an old textbook the other day, "Principles of Chemistry," by J. A. Porter, M. D., published in 1866. It was perhaps a very good text in its day. There are over *three hundred* experiments in the book and the title page announces that this is a revised edition containing many new "Parlor and lecture experiments!" And so chemistry once had a place in the parlor! Well, that was before its widespread use as a high school subject so perhaps it is true. But the interesting thing about this book, to a modern reader, is this: The experiments invariably precede the explanations, and the facts brought out by these experiments are the same today as they were in 1866, but the explanations which follow in this old book would be laughed out of court now. We have a different scheme, perhaps a more efficient scheme, for thinking about these facts, new mental formulas for linking the old with newer facts.

But we do not need to go back three-quarters of a century to this old book to discover the uncertainty of theories. Take a recent issue of the *Science News Letter*, January 5, 1924. On page three we have this title "New Slant to Evolution Given by Fossil Bones." Not fossilized teachers, mind you but "fossil bones." Page 5 continues the argument for the affirmative with the caption "Sun Spots Show Strange Reversal of Magnetic Poles" and the article affirms that the "new observations are revolutionary and the findings to be unexplained." Again in this same issue we have another illustration—"Strange Star Upsets Astronomical Theories." The article discusses the companion of a certain variable star and after mentioning one *new* theory concludes that it may be necessary "to form a *third* hypothesis, to account for its existence and peculiar behaviour." Evidently theories are not as fixed as the variable stars even.

Now as though this were not enough for once the very next topic startles us by announcing, "Pigeons Change of Sex Upsets Heredity Theory" What a hard time the theories are having.

Since the astronomers have come to the support of Einstein, we may say, in the language of the old song, even old gravitation ain't what she used to be. But this change exists largely in man's mental machinery. As far as there are records to show, the *experience* of falling from a ten story window is about the same as it has been in the past.

Suppose we turn now to some more dignified statements of the fundamental psychology of the situation. In the High School Research Bulletin, Vol. I, No. 20-C of the Los Angeles City Schools, by Franklin Bobbitt we find this:

"4. The basis of all science learning must be *abundant experience* with *concrete realities.*

1. Working with them. Using them. Controlling them.
2. Play that involves them.
3. Observations of them.
4. Abundant *revealing reading.*

"5. Practical activities which involve the use and control of the science realities should be as abundant as practicable. (Fundamental realities).

Please note the word *revealing* in (4) above and then go back to John Dewey. We will find this: "General appeals to the pupil to think irrespective of the existence, in his *own experience* of some difficulty that troubles him and disturbs his equilibrium are as futile as advice to lift himself by his bootstraps."

But must we learn every thing in science—every fact, invention, or application, by experience with *each*? Not by any means; such a process would compel each generation to begin all over in adapting itself to its environment and progress would be impossible. There are some fundamental, or alphabet, experiences. Through our early experiences in falling from a chair, a horse, or the old apple tree, we have learned that to fall from a ten story window would be unpleasant, if not disastrous. This is our experience. When we read of an individual who has had this actual experience it is *revealing* reading to us because of our experiences. Could we explain it to one who had always lived in a neutral gravitational field and who had no concepts of falling, of impact, or injury to one's self?

The task of the teacher of science, then, is to see that his pupils acquire as many of the elements of experience as possible from the general environment,—"to satisfy as many curiosities as possible"—that curiosity without which mind would not be mind and without whose satisfaction there could be no progress.

"Happy is the man who knows the causes of things," said Vergil. And all this may come to our pupils if we will permit them to make facts their own by allowing them the pleasure of catching these facts themselves. This is the best stimulant not only for the curiosity, but for the other mental processes teachers hold so dear; this enthusiasm will preserve not only the facts in the memory, but also the interest in, and appreciation of science for a life time.

And now, whether we have bagged any game or not, it is time to assemble around the campfire while "Ulysses, much-experienced man" summarizes for us:

"I am part of all that I have met,
Yet all experience is an arch wherethro'
Gleams that untravelled world whose margin fades
Forever and for ever, *when I move.*"

SCIENTIST TRANSPLANTS BEATING HEART INTO NEW BODY.

A living, beating heart has at last been transplanted from one living body into another.

Into a body already supplied with a heart, Dr. P. Stohr of Wurzburg, Germany, placed a beating heart taken from another body. And he succeeded in keeping both hearts alive, functioning in the same body. Dr. Stohr has also succeeded in isolating the heart system from the organism and developing it outside the body for a considerable length of time.

The experiments were on embryo salamanders. Although there is a wide gap between salamanders and man, it is the ultimate hope of all such experiments that the same thing may eventually be accomplished in the case of man. However far the present discovery may be from such an eventuality because of the numerous intricate problems that must first be solved, it is of great interest and import.

Dr. Stohr first attempted to confirm the findings of another scientist named Ekman who had demonstrated successfully that the undeveloped embryonic heart of salamanders is capable not only of remaining alive outside the organism but also of developing into its several parts. Stohr succeeded in the case of salamanders and tritons in seventy cases and kept hearts alive for as long as three weeks.

In other cases Stohr transplanted the heart from one embryo to another, thus producing larvae or tadpoles with two hearts each. These tadpoles successfully kept alive for a period of time long enough to show the result of an extra heart on the development of the animal. During these experiments Stohr learned several noteworthy and interesting facts. He found that the power to perform regular contractions is the inherent property of each heart cell and not a function of the nervous system or of the immediate surroundings of the heart.

He also learned that there was an extraordinary regularity of pulse beat in the excised hearts. It only five cases out of the seventy were there irregularities, and these exceptions were capable of explanation. He also noted that each heart cell or entire heart has a rhythm all its own and cannot be influenced by the rhythm of another heart in the same body. Neither heart cares what the other heart is doing. A rise of temperature causes the pulse rate of both hearts to increase but in the same proportion in each case.

A LABORATORY EXPERIMENT FOR TESTING THE EFFICIENCY OF A SCREW JACK[1].

A. P. CARMAN AND R. F. PATON,

University of Illinois.

Our object in devising this experiment has been to get a feasible quantitative college experiment which would fix the principle of work and the concept of efficiency of a machine. We chose as the machine a small screw jack, the particular jack being an inexpensive one used to lift light weight automobiles.

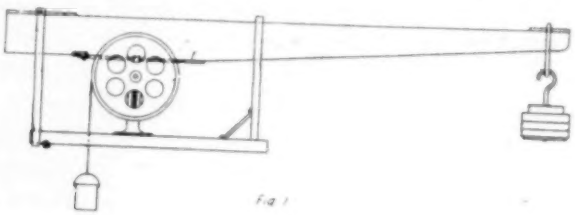


Fig 1

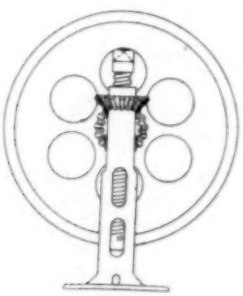


Fig 2

The apparatus is shown in Figs. 1 and 2. The hand lever was removed from the gear wheel of the jack and a disk was substituted. The "power" force is applied as a weight hung by a wire cord which is wound in a groove on the periphery of the disk. This applies a moment of force to the small gear wheel which acts in turn on the gear turning the screw on the jack. The "weight" force which is overcome consists of a number of large iron weights hung on the end of a lever. The fulcrum of this lever is at the opposite end of the bar and the "power" force on the lever is the force exerted by the jack. The lever as constructed by us consists of an oak beam 1.5 inches thick, about four inches wide and about seventy inches long. The upper end of the jack screw was fitted with a wedge-shaped piece and this rests on an iron plate screwed on the lower part of the oak beam. The point of appliaction of this "power" force

[1]From Illinois State Academy of Science Transactions, Vol. 17.

can thus be shifted along the lever bar; this point of application will not in general be under the center of gravity of the lever bar so that the work done in raising the center of gravity must be taken into account in the final calculations of the efficiency of the machine.

The following is a sample set of readings made with this apparatus:

Weight of lever	6490 grams
Pitch of screw	.847 cm
Distance of fulcrum to jack	46.0 cm
Distance of fulcrum to center of gravity of lever	66.0 cm
Distance of fulcrum to weight	166.0 cm
Distance "weight" is shifted for two revolutions of disk	6.35 cm
Distance "power" force moves for two revolutions of disk	177.8 cm
Weights at end of lever	12410.0 cm
"Power" weights in bucket required to just lift above "weight"	2040.0 gm

From the above data, the student calculates directly the following:

Ideal mechanical advantage of jack	105.
Actual mechanical advantage of jack	26.8
Ideal mechanical advantage of lever	.266
Actual mechanical advantage of lever	.230
Ideal mechanical advantage of combined machine	28.0
Actual mechanical advantage of combined machine	6.08
Efficiency of jack	25%
Efficiency of lever	86%
Efficiency of combined machine	22%

Laboratory of Physics,
University of Illinois.
April, 1924.

SOME RADICAL DEPARTURES ON THE TEACHING OF BIOLOGY.[1]

By Elliot R. Downing,

University of Chicago.

The psychology of science teaching is now sufficiently clarified and the experimental determination of the relative values of method of instruction sufficiently advanced to warrant certain radical changes in our courses of study in biology and the technique of presentation.

All subject-matter should be eliminated from the course that is not socially worth while, and at the same time of prime interest to the pupils. The only justification for the taxation of the people to cover the expenses of the education of their children, is that education contributes to the efficiency of those educated as members of the community. Interest is a prime prerequisite. For any educational process is the result of self

[1]From Illinois State Academy of Science Transactions, Vol. 17.

activity and that is conditional in its intensity by interest. We know from the studies of Mau, Finley, Traften, and others, that pupils are interested primarily in the activities of animals and plants, their identification and relation to the environment —not in their structure, classification, utility, Further, that the interest is chiefly in birds, insects, and common mammals among the animals, and in wild flowers, trees and garden plants. Our biology should deal largely with these groups and it should be chiefly concerned with behavior and environmental relationships.

The subject-matter should be organized in relatively small units, with topic titles that challenge attention, for the mental grasp of High School sophomores is not extensive. The pupil needs to progress by small, well defined steps, so he may have a constant sense of mastery and not feel lost in the intricacies of a hazy, large subject.

The unit, or a small group of them, should eventuate in a comprehension of a biological law or generalization of major social importance, because in proportion as one gets his knowledge generalized, is it applicable to a new situation, and then only as he has had drill in such application. The teacher must therefore spend time in carrying over these biological generalizations into life situations. A few such general laws well selected for their social values, well mastered and applied, are of real value. A mass of unorganized biological detail is useless.

Many of these units should be organized in problem or project form to give drill in accurate methods of scientific thinking, for such ability is more important than the acquisition of knowledge. Some units should be organized with a view to giving an aesthetic appreciation of one's environment. Others to give an appreciation of the value of science and of the devoted labors of scientists; some to develop a sense of the lawfulness of nature, and the moral obligation of the student to obey her laws.

The recent experiments of Cunningham, Cooprider, Anibal, and others, have shown that as far as the acquisition of knowledge is concerned, the lecture demonstration is more efficient than the laboratory method of instruction, and much more economical of time and material. Science instruction is neglected in the small High Schools because of the unjustified notion that expensive laboratory equipment is essential. The cost of instruction per pupil in the sciences is well toward the top of the list in high school subjects. The writer is convinced

that we waste a large amount of time of students in muddling around in the laboratory. Teach them by the lecture demonstration method. Reduce laboratory work to a minimum. Bar the compound microscope from the High School biology course, and replace it with the demonstration projection microscope. Omit all dissections by students; such a dissection is rarely instructive—it is futile hash. Use prepared dissections when structure is to be studied, remembering that such studies are only to be made when structure is essential to a comprehension of activities. Omit from the note books all detailed sketches and replace them with diagramatic drawings. Ayers investigation has shown that such drawings are much more efficient in fixing in mind the essential points.

In working out problems and projects, the early work should aim to habituate the pupil to the solution of a problem in the logical way, by following the detailed guidance of the teacher. Gradually the teacher's help should be withdrawn as the student is instructed in the essential steps of the problem solving process. Finally the pupil should be led to work out his individual problem or project unaided.

THE RELATION OF FLUE GAS ANALYSIS TO THE EFFICIENCY OF THE OIL BURNER.

By George T. Parker and H. A. Geauque,

Lombard College, Galesburg, Ill.

Introduction.

The extensive use of fuel oil in all types of furnaces gives economic importance to standards of furnace control. The small installation is seldom controlled from the measurements of a testing engineer as the variations in the efficiency of the installation seldom amount to enough to warrant the employment of an engineer, The large installations, however, are being controlled by the modern methods which have been developed for coal fired furnaces. These methods are tests of the intensity and quantity of combustion and, when applied to the combustion of fuel oil, indicate the efficiency of the furnace, provided, of course, they are interpreted in the right way.

Because of the rapid development of the oil burner industry, the discussion of the efficiency of the oil combustion has been left largely to the salesmen or promoters, while the factory engineers have been busy developing the production efficiency of the plants. Efficiency standards have been set by argumen-

tation rather than being based upon information gained in the industrial laboratory. As a result many exaggerated claims have been made regarding the efficiency of the oil furnace, including claims of more than 17% carbon dioxide in the flue gas. Of the many claims of advantage of the oil burner over the coal fired furnace the flue gas analysis should show the relation in efficiency of starting, change in load, and complete combustion.

Combustion Efficiency.

The type of fuel used varies considerably, but with the lighter fuel oils, the average hydrocarbon indicated by the properties of the oil is probably represented by the formula $C_{16}H_{34}$. The quantity of this oil, or the percentage, cracked during vaporization, probably varies considerably, but the ease with which it is distilled would indicate that it is stable at the moderate temperatures. The vaporization in the burner is at a point where a large quantity of air is being admitted to the fire pot. The cool air keeps temperature of this part of the fire pot very much lower than that of the flame. On the assumption that only a very small per cent of the hydrocarbon is cracked, the maximum percentage of carbon dioxide in the cooled flue gas can be calculated by calculating the combining volumes from the equation:

$$2C_{16}H_{34} + 49O_2 = 32CO_2 + 34H_2O$$

If we assume that the ratio of oxygen to air is 1 to 5, the reaction will be expressed by volume as follows:

2 volumes Distillate + 245 volumes Air =

32 volumes CO_2 + 196 volumes N_2 and inert gases.

This gives us a ratio of 32 volumes of CO_2 in a total of 228 volumes of flue gas which gives a percentage of 14.03% carbon dioxide, as the maximum per cent possible in the cooled flue gases. The maximum carbon dioxide from oil combustion is calculated by F. D. Harger [1].

as 15.395% from the analyses of the oil given as C = 84.0; H = 14.0; O = 1.2; S = 0.4; N = 1.7. The calculation of the maximum per cent of carbon dioxide possible from the combustion of the above oil is 12.52%.

The cracking and dissociation at the high temperature of the flame give the combustion a process of oxidation of carbon and hydrogen as dissociated in the flame rather than a molecular reaction. This change in the condition of these elements would

[1] F. D. Harger, Fuel Oil, Vol. 11, No. 6, P. 9.

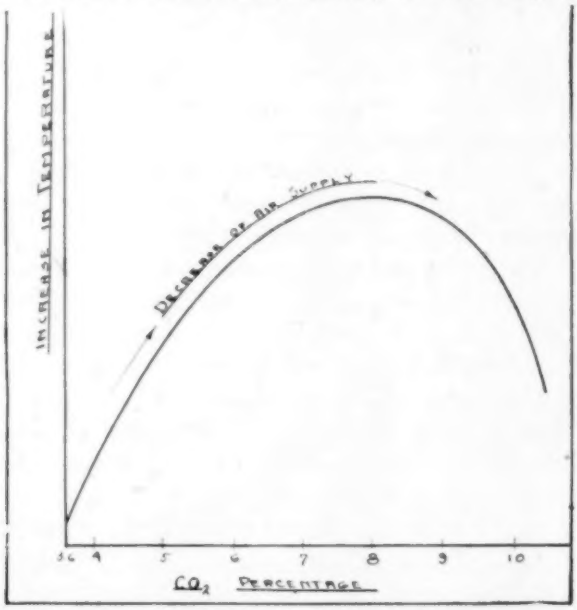
not, however, change the resultant compounds found in the flue gases.

Experimental.

Two types of burners were studied—the vaporization and the spray types. The temperatures were measured by means of a thermo-couple and potentiometer. A modified form of the Orsat gas analysis apparatus was used in analyzing the flue gases.

In the spray type, found in the market, at present, the oil being sprayed by air pressure, the quantity of air seems to be governed by the necessity of spraying the oil rather than by the amount necessary for combustion and by attempts to lower the air supply. The study of the effect of the air supply upon the efficiency, resulted in the stopping of the spray, and the burner, of course, was extinguished. The maximum carbon dioxide from this type of burner was found to vary between four and five per cent, 4.6 being the average. These conditions can probably be made more favorable by several adjustments, but it was found impossible by the author to keep the oil supply constant and change the amount of air supplied to the burner. In this type of burner, the oil supply, of course, depends upon the velocity of the air current.

In the studying of the vaporization type of burner, the air could be controlled and the relationship of the temperature to



the quantity of air necessary for the maximum efficiency was easily found. Figure 1 shows the relationship between the temperature and the percentage of carbon dioxide in the flue gas. The oil supply was held constant during these readings and the air supply was diminished. The maximum air supply that the burner could possibly use was used as a starting point and the readings were taken as the air supply was diminished. As is indicated on the curve, both the percentages of carbon dioxide and the temperature were found to increase to approximately 8.3% carbon dioxide. After that a quick break in the curve indicating a lower temperature, shows that above this point, at least, the efficiency was quickly lowered on the carbon dioxide curve between 6.6 and 8.3%. There was only a comparatively small change in temperature and this would indicate that an average in this range would be perhaps the most efficient in this condition. The conclusion from a study of the flue gases of the ordinary marketed types of oil burners can be summed up as follows:

1. A control of the air supply is very advantageous.
2. The air supply should be such that the carbon dioxide in the gas should come between 6.6 and 8.3%.
3. The construction of the burner should be such that a change in regulation should not affect the mechanical action of the burner.
4. An excess of forced air should be avoided because of the serious cooling effect it has upon the flue gas.

DO WE TRAIN OR DO WE MERELY SELECT?

By Harold Sellers Colton,

University of Pennsylvania, Philadelphia.

Introduction.

In a preceding paper (Foot Note No. 1) an investigation was presented which shook considerably our faith in the ultimate end of education. A comprehensive examination could show no significant difference between students who had passed through a laboratory course in General Zoology where training was particularly stressed and a laboratory course whose object was mainly to impart information. In attempting to train students in General Zoology, are we attempting the impossible?

At the University of Pennsylvania the course in General Zoology has been constructed on the following aims. The course endeavors to modify the behavior of a group of organisms called students, so that they may be better adopted to their environment. Within the limits prescribed by time, equip-

[1]Colton H. S. Information and Training. School and Society, Vol. X, Page 10.

ment, and personnel, it attempts to train those students to use their eyes, which many never have used before, to record and organize what they see,—and, what is most important of all, to generalize from observed, verifiable facts:—all of which form the very essence of scientific method. At the same time it further attempts to give to those students an intellectual background which shall include the mechanism of their own bodies, hereditary transmission, the concept of evolution, and the position of the student in a world with other animals. These are its aims.

The Material:

Before we determine what we do, we must examine the behavior of the wild organisms as they enter our class. We know that they have not the same heredity; nor do they come from the same environments; they have not had the same training. Some are adapted by their hereditary constitution, to our subject from the start. Other achieve adaptation (a word used in the sense—the fact of fitting), and many, it is to be regretted, never fit at all. It brings us to the old story of "Nature" and "Nurture."

The fact of "Nature" we can grant. (1) Students are congenitally different. (2) On the basis of these differences selection has been practised in the schools. Certainly elimination on the basis of congenital differences is a fact.

On the theory that "Nurture"—training—is effective, we, the instructors, hold our present jobs. The amount of training in biology in school which carries over into college forms a convenient measure. Because we are depressed by half forgotten information and incomplete conceptions,—some by-products of school instruction, we overlook, perhaps, the effect of training, the unforgettable products of school education. That something from school biology carries over into college has been demonstrated by Matthews (Foot Note No. 2) and the author (Foot Note No. 3). There seems to be something in "Nurture."

Observations:

In the winter of 1919-1920 the author further studied the class in General Zoology, carrying the comparison between students who have had zoology in school, with those who had

[2]Matthews E. J. The Correlation of High School and College Courses in the Sciences. University of Texas Bulletin No. 1838, 1918.

[3]Colton H. S. The Bearing of High School Science on a College Course in General Zoology. School and Society, Vol. 2, Page 69, July 10, 1915.

none into smaller groups of students. He examined the premedical students, which form nearly half the class and who have a similar aim; he examined the balance of the class—the nonpremedicals; the students who work for the love of the subject came under his scrutiny; Philadelphia High School males were studied separately from the females.

Of all the groups studied the Phildaelphia High School males alone showed any significant difference (Foot Note No. 4) in performance between those students who had had zoology in school and those who reported none. In all other cases the difference was less than three times the probable error of the difference.

In 1922-1923, the students after a simple practical test were segragated on entrance into the course on the basis of ability to do zoological work. The students from Philadelphia High Schools who formed but a quarter of the whole class found themselves occupying nearly half of the superior section. This group of students from certain High Schools invariably do better work in our course than others.

Table No. I.

	Percentage of students who made the superior sections in the preliminary test. The superior sections contained about one fourth of the students.			Percentage of students who received D or G in the course in General Zoology The group contained about one third of the students in the course.	
	Had Zoology in School	Had No Zoology in School	Number of Students in Superior Sections	Had Zoology in School	Has No Zoology in School
Phila H. S.	45%	19%	56	50%	31%
Other Metropolitan H.S.	7%	25%	34	28%	30%
Small City	17%	33%	41	35%	44%
Private Schools	17%	27%	23	17%	9%

It is seen from the figures in Table One that the students from the Philadelphia High Schools are the best prepared at entrance to undertake zoological work in this course and that they maintain this lead to the end of the course.

[4]A difference of over three times its probable error was considered significant.

For the past eight years the students have been classified under their high school teachers. The number of students who receive Distinguished or Good—the upper third of the class,—form a convenient measure. To be sure it varies a little from year to year, but on the average it contains 34% of the class, which is very close to one third.

Table No. II.

Certain Teachers in Philadelphia High Schools	A	B	C	D	E	F	G	H	Class as Whole
Percentage of Students in the D G Class	50%	69%	59%	83%	50%	50%	60%	60%	34%

The teachers selected in Table 2 are those who have sent the most students to our course. Teachers A, B, C, and D are from the same school. Teacher D, with 83% of his students in the Distinguished and Good class is the most experienced of the four.

Conclusion:

Outside the larger metropolitan high schools the author is led to believe that laboratory work has but a small place in biological courses. This conclusion has been arrived at through conferences with the students. Except in a few cases no special training is given in Biology—the courses being mainly informational, and information is soon forgotten, particularly so as Biology comes early in the High School curriculum. It seems certain now that some schools do train their students in Biological methods. Our faith in our teaching is strengthened. If the schools can train when they try, so can we do more than select. We can modify the behavior of some students; this is comforting to know.

N. HENRY BLACK

Mr. N. Henry Black, who has been science master at the Roxbury Latin School, Boston, Mass., for the past twenty-four years, has been appointed Assistant Professor of Education at Havard University. During the coming year two-thirds of his time will be devoted to teaching physics and the rest to courses on the teaching of science in secondary schools.

PROBLEM DEPARTMENT.

CONDUCTED BY J. A. NYBERG,
Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mahematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to J. A. Nyberg, Hyde Park High School, Chicago.

LATE SOLUTIONS.

813, 829. *George Sergent, Guatemala.*

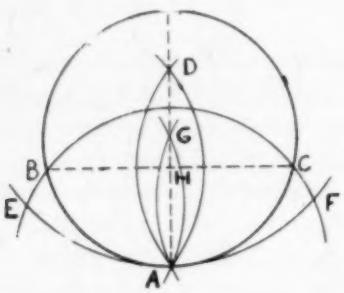
SOLUTION OF PROBLEMS.

831. *Proposed by M. Freed, Wilmington H. S., Los Angeles, Cal.*

Find the center of a circle using compasses only.

Solved by Michael Goldberg, Philadelphia, Pa.

With A, any point on the circle, as a center and with any convenient radius draw a circle cutting the given circle in points B and C. With B and C as centers and AB as a radius draw two arcs, intersecting at D. With D as center and AD as radius draw an arc intersecting at E and F the circle whose center is A. With E and F as centers and EA as radius draw arcs, intersecting at G. This is the center of the given circle.



Proof: $\triangle DEA \sim \triangle GEA$ because both are isosceles and $\angle EAG$ is common. Then $EA^2 = AD \times AG$. Call H the intersection point of AD and BC. Then $AD = 2AH$; hence $EA^2 = 2AH \times AG$, or

$$2AH \times AG = EA^2 = BA^2 = AH + HB^2 = AH^2 + BG - HG^2$$
$$= AH^2 + BG^2 - (AG - AH)^2$$
$$= BG^2 - AG^2 + 2AH \times AG$$

Hence $BG = AG$. Similarly, $CG = AG$.

All geometrical constructions which use only the compass and straightedge (Euclidean Geometry) can be performed by the compass alone.

Also solved by *Philomathe, Montreal, Can.*, and the *Proposer.*

832. *Proposed by W. T. Harlow, Portland, Ore.*

In our decimal system of currency the removal of the decimal points does not change the value of any expressed amount of money reduced to cents. For example, removing the decimal point from $90.60 we have 9060 cents. In English money there is only one amount which admits of the removal of the dividing points or units, reducing the figures to farthings without disturbing the expressed value. Find the amount.

Solved by N. H. Mewaldt, State Normal School, Dickinson, N. D.

Let x = number of pounds, y = number of shillings, z = number of pence, and w = number of farthings. $y < 20$; $z < 12$; and $w < 4$.

The value of the money in farthings is $960x+48y+4z+w$ which must be equal to one of the following four expressions (according as y and z are numbers of 1 or 2 digits):

$1000x+100y+10z+w$; $10000x+100y+10z+w$;

$10000x+1000y+10z+w$; $100000x+1000y+10z+w$.

None of these four expressions are possible for when combined with

(1) $960x+48y+4z+w$

at least one unknown must be negative.

Assume $w=0$; that is, we are not dealing with farthings.

Then $960x+48y+4z+w$ must equal:

(2) $100x+10y+z$ ($y=0$..... 9; $z=0$..... 9)
(3) $1000x+10y+z$ ($y=10$.....19; $x=0$..... 9)
(4) $1000x+100y+z$ ($y=0$..... 9; $x=10$ or 11)
(5) $10000x+100y+z$ ($y=10$.....19; $x=10$ or 11)

Of these, (2) leads to negative values when combined with (1); likewise (4) and (5). Equating (3) and (1) leads to

$$40x=38y+3z \text{ or } x=y+\frac{3z}{40}-\frac{2y}{40}.$$

Hence $x=y$, and $3z=2y$. The only solutions (remembering that $y=10$.....19) are $x=12$, $y=12$, $z=8$.

Also solved by *J. Murray Barbour, Ardmore, Pa., W. T. Harlow, Portland, Ore., C. E. Githens, Wheeling, W. Va., J. F. Howard, San Antonio, Tex., and E. Rae, San Jose, Cal.*

833. *Proposed by J. K. Ellwood, Philipsburg, Mont.*

A and B start to walk around a circular path one mile in circumference. Each reduces his rate one mile per hour at the end of the first hour, and again one mile per hour at the end of the second hour.

They start in the same direction. Twelve minutes after A has passed B the 3rd time A turns and walks in the other direction until 6 minutes after he has met B the 3rd time again, whereupon he turns to his original direction and overtakes B four times more. Find the rate of each if each has walked 3 hours and A has walked 8 miles more than B.

Solved by J. F. Howard, San Antonio, Tex.

Let the rates of A and B be respectively x and y during the first hour, $x-1$ and $y-1$ during the second hour, $x-2$ and $y-2$ during the third hour. Since A's rate exceeds B's by the same rate during the entire 3 hr., $x-y=8/3$.

Since A gains 8/3 mi. per hr. on B he will overtake B every 22½ min., and therefore will pass him the third time (counting the starting pont as the first passing) in 45 min. During the next 12 min., A will gain

$$\frac{12}{60}\times\frac{8}{3} \text{ or } \frac{8}{15} \text{ mi. on B.}$$

A now reverses his direction. For the 3 min. left of the first hour they approach each other at the rate of $(x+y)$ mi. an hr., and will cover $(x+y)/20$ mi. in that time. This leaves $8/15-(x+y)/20$ mi. to go to meet one another, and $2+8/15-(x+y)/20$ mi. to meet the third time. As their rate toward each other is now $x-1+(y-1)$ or $x+y-2$ mi. an hr., this will require

$$\frac{60\left(2+\frac{8}{15}-\frac{x+y}{20}\right)}{x+y-2}$$

or $(152-3x-3y)/(x+y-2)$ min. In this way they continue for 6 min. traveling $(x+y-2)/10$ mi. To pass B 4 times, or gain 3 laps, requires 67½ min. or more than one hour; hence their rates have not changed during this time.

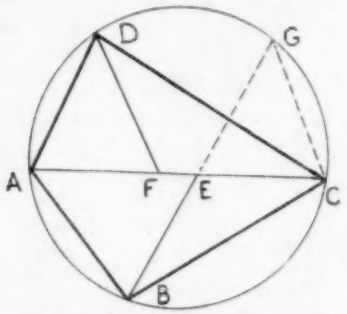
A now reverses his direction again and must gain $3+(x+y-2)/10$ miles to pass B 4 times; he gaining a mile in each 22½ min.

The total time is 180 min.; hence

$$45+12+3+\frac{152-3x-3y}{x+y-2}+6+22\tfrac{1}{2}\left(3+\frac{x+y-2}{10}\right)=180$$

Letting $x+y-2=k$, this reduces to $9k^2-198k+584=0$ whose roots are (approximately) 3.5 and 18.5. The value 3.5 leads to a negative rate for B during the 3rd hour. Hence $k=18.5$, or $x+y-2=18.5$. Solving this with $x-y=8/3$ we find A's rate at the start was about 11.58 mi. an hr. (Rather fast walking).

Also solved by *J. M. Barbour* and *N. H. Mewaldt.*



834 *Proposed by F. A. Cadwell, St. Paul, Minn.*

ABCD is a quadrilateral inscribed in a circle. F and E are points on AC such that $\angle ADF = \angle BAC$, and $\angle ABE = \angle DAC$.

Prove that AF = CE.

I. *Solved by Arria Murto, Hickman Mills, Mo.*

Let $x=\angle ADF=\angle BAC$, and $y=\angle ABE=\angle DAC$.

$\triangle ADF \sim \triangle BAE$ since two angles of one equal two angles of the other. Hence $AF/FD=BE/AE$.

$\angle ADF+\angle FDC+\angle ABE+\angle EBC=180°$ since the quadrilateral is inscribed in a circle, or $x+y+\angle FDC+\angle EBC=180°$.

$\angle EAB+\angle ABE+\angle EBC+\angle BCE=180°$ being the sum of the angles in $\triangle ABC$, or $x+y+\angle EBC+\angle BCE=180°$.

From the last two equations, $\angle FDC=\angle BCE$.

Also $\angle DFC=\angle BEC$ since each equals $x+y$.

Hence $\triangle DFC \sim BEC$ and $FD/CE=FC/BE$.

The product of (1) and (2) leads to $FC/AF=AE/CE$. If we here add the denominators to the numerators, we get

$AC/AF=AC/CE$; hence $AF=CE$.

II. *Solved by Walter H. Carnahan, Bloomington, Indiana.*

Extend BE to meet the circle at G. Draw GC. Then

Arc AG = arc DC since they are intercepted by equal angles.

Arc AD = arc GC, by subtracting arc DG; hence AD = GC.

$\angle BGC=\angle BAC=\angle ADF$, and

$\angle ACG=\angle DAC$.

$\therefore \triangle GCE=\triangle ADF$ or $CE=AF$.

Also solved by *Autoon J. Cave, Houghton, Mich., Kenneth Crouse, Indianapolis, Ind., T. E. N. Eaton, Redlands, Cal., Michael Goldberg, Alice Gould* and *Eleanor Maderer, Watertown, N. Y., Clarence F. Holmes, Elizabeth City, N. C., J. F. Howard, N. H. Mewaldt, Charles Shields, Indianapolis, Ind., George Sergent,* and the *Proposer.*

835. *For High School Pupils. Proposed by Betty J. Sharp, pupil at the Miami H. S., Miami, Florida.*

Construct a triangle having given a side, an adjacent angle, and the difference of the other sides when the greater side is opposite the given angle. (Using only material found in the first half year of geometry.)

Solved by Theodore Darby, Redlands H. S., California.

Construct $\angle BAE$ equal to the given angle, and AB equal to the given side. Prolong EA and make AD equal to the given difference of the

two sides. Draw DB. Draw the perpendicular bisector of DB and call C its intersection point with AE.

Then $\triangle ABC$ is the required triangle.

Proof: DC = CB for any point on the perpendicular bisector of a line is equi-distant from the ends of the line.

CB — AC = AD, the given difference of two sides.

PROBLEMS FOR SOLUTION.

846. *Proposed by George Sergent, Guatemala.*

Given $\triangle ABC$ and a line RS. A line is drawn parallel to RS intersecting AB at P and BC at Q; and Q is joined to A. Determine the position of P and Q so that PQ + QA equals a given length, *l*.

847. *Proposed by C. E. Githens, Wheeling, W. Va.*

Prove that the product

$$2^{\frac{1}{2}} \cdot 4^{\frac{1}{4}} \cdot 8^{\frac{1}{16}} \cdot 16^{\frac{1}{32}} \cdot \ldots\ldots \text{ to infinity}$$

equals 2.

848. *Proposed by Norman Anning, Ann Arbor, Mich.*

Solve: $\tan x + \tan 4x = 2 \tan 3x$.

849. *Proposed by Burrell Morgan, Krollitz, W. Va.*

If a man charges $2 for sawing a cord of wood consisting of 3 foot lengths into 3 pieces, what should he charge for sawing a cord consisting of 6 foot lengths into 4 pieces. Derive also a formula for the general problem, and base the solution on proportions, if possible.

850. *For High School Pupils. Proposed by Paul Ligda, Oakland, Cal.*

Two competing merchants are selling suits of the same kind and at the same price. Each sells 12 suits. Then A cuts the price $3 on each suit and sells 8 suits at the new price. B cuts his price $6 on each suit and sold 18 at the new price. If the total sales in dollars are the same for both, what is the amount of the sales?

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

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You are asked to answer questions.

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QUESTIONS FOR SOLUTION.

448. *Proposed by Fred S. Jones, Hastings, Mich.*

How silver a mirror without using ethyl alcohol?

449. *Proposed by R. Beatrice Miller, West Philadelphia High School for Girls, Philadelphia, Pa.*

How can a gravity cell be filled with the least possible mixture of the zinc sulphate and copper sulphate solutions?

450. *Proposed by R. Beatrice Miller.*

What scheme can be suggested for keeping odds and ends of electric wire in good order?

451. *Proposed by R. Beatrice Miller.*

Wanted—Some short, concrete projects on the subject of "sound."

EXAMINATION PAPERS.

PHYSICS—College Entrance Board 1924.

(3 hours)

Answer ten questions as indicated below. No extra credit will be given for more than ten questions.

Indicate clearly your reasoning in each problem and state the units in which each answer is expressed.

Number and letter each answer to correspond with the questions selected.

PART I.

(Answer all questions in this part)

1. *a*) State the Law of Conservation of Energy.
   b) Assuming that this law is true how can you explain the fact that a 700 pound load can be lifted with an effort of only 100 pounds by means of a certain system of pulleys?
2. *a*) At what average horse power does a man work who loads 30 bricks a minute from the ground to a wagon 4 feet from the ground? Each brick weighs 7 pounds.
   b) What is his efficiency if he tosses them 1 foot higher than necessary?
3. Two electric light wires exert upon a pole two forces at right angles to each other which are in the ratio of 3 to 4. If the total force exerted upon the pole is 125 pounds, how much force does each wire exert?
4. Explain the meaning of each of the following statements:
   a) "The specific heat of ice is 0.5."
   b) "The coefficient of cubical expansion of a gas under constant pressure is 0.00366."
   c) "The mechanical equivalent of heat on the basis of pounds feet, and degrees Fahrenheit is 778."
5. *a*) State a rule for finding the direction of the magnetic force near a conductor carrying an electric current.
   b) State Lenz's Law and give some illustration of its application.
6. *a*) State two reasons for believing that sound is carried in air by a wave motion.
   b) In order to locate an obstruction in a water pipe a pistol was fired near the open end of the empty pipe, the temperature of which was 10°C. A sound was heard 3 seconds later. How far from the end was the obstruction?
7. *a*) Describe a method of finding by experiment how the intensity of illumination, due to a small source of light, varies with change of distance from the source.
   b) If the page of your book is sufficiently illuminated at a distance of 3 feet from an 8 candlepower lamp, how many candlepower will be needed when you move 2 feet farther away?

PART II.

(Answer three questions from this part)

8. The specific gravity of ice is 0.918, that of sea water is 1.03. What is the total volume of an iceberg of which 700 cubic yards are exposed above the water?
9. A 14 inch shell weighing 1,400 pounds, after traveling one-twentieth of a second in a cannon, leaves the muzzle with a velocity of 2,600 feet per second.
   Find
   a) its acceleration
   b) its kinetic energy as it leaves the muzzle.
10. If one gram of kerosene supplies 11,000 calories of heat, how many grams of water, originally at 20°C., can be boiled away by burning 400 grams of kerosene in a stove having an efficiency of 70 per cent?
11. A current is passed through two electrolytic cells connected in series. One cell contains copper electrodes in a solution of copper sulphate, and in the other cell there are platinum electrodes in a solution of sulphuric acid. Describe the phenomena which takes place at each of the four electrodes.
12. A transformer having 840 turns of wire as a primary is used to transform a current of 1,200 volts to 110 volts.

a) How many turns of wire should there be on the secondary?
b) If 100 lamps of 50 watts each are connected in parallel on the secondary, what current will flow through the primary if there is no loss in the transformer?

13. Stations *A*, *B*, and *C* are one mile apart in a straight line. An enemy's cannon is heard at *A* and *C* at the same instant, but two seconds sooner at *B*. Find the exact position of the cannon with reference to these three points.

14. *a*) What kind of lens is used as a "reading glass"?
b) What kind of an image does it give when used as a reading glass
c) How far from a printed page should a reading glass of 5 inches focal length be held in order that the image of the letters may be ten times as high as the actual letters?

15. *a*) Define index of refraction of a substance.
b) If the velocity of light is 186,000 miles per second, what is the velocity of yellow light through a diamond, a substance whose index of refraction for yellow light is 2.47?
c) If red light, with index of refraction 2.40, were present with yellow light, what action would the diamond have on the mixed beam on light?

SOLUTIONS AND ANSWERS.

441. *Proposed by Ferdinand Jehle.*

A dirigible condenses the water in the exhaust gases and retains them on the ship. Does the dirigible become lighter or heavier?

Solution by George H. Gatje, Friends School, Brooklyn, N. Y.

Answer: It becomes heavier.

Proof:

Gasoline consists largely of the paraffins of about order $C_{10}H_{22}$ to as high as $C_{27}H_{56}$. The general combustion equation may be written:

$$2CxHy+(y/2+2x)\ O_2 \rightarrow yH_2O+2xCO_2\uparrow$$

When x is any positive integer and $y=2x+2$.

A weight of gasoline corresponding to $2CxHy$ is on the dirigible. This weight is after combustion replaced by yH_2O. From this it will be noticed no hydrogen escapes, so that the whole problem is just a matter of putting yO in place of $2Cx$. Now since y is slightly greater than $2x$, and since the atomic weight of O is greater than that of C,

$$yO > 2C_x$$

or $$yH_2O > 2C_xHy.$$

This will also hold true for those of ethylene (C_nH_{2n}) and benzene series—(C_nH_{2n}—6) series,—which may be present in small quantities. In case of Ethylene series $y=2x$, but yO will be greater than $2Cx$ due to O having the greater value. In the case of the benzene series $y=2x-6$ and hence yO is not necessarily greater than $2Cx$. Solving for critical value of x for this series, it is found to be 12. This means that for the compound $C_{12}H_{18}$, there will be neither an increase nor a decrease in weight. Any compounds lower in the series will cause a decrease in weight while any higher will cause an increase. Since members of this series are only present in gasoline in small quantities, it may be safely stated that condensing the water will increase the weight of the dirigible.

Also solved by J. E. Running, Fargo, North Dakota.

ANNOUNCEMENT.

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ARTICLES IN CURRENT PERIODICALS.

American Botanist, Joliet, Ill., for July, *$1.50 per year, 40 cents a copy.* "The Pioneers of Botany," "Plant Names and Their Meanings XX Malvaceae," Willard N. Clote, "Conspicuous Tropical Plants."

American Journal of Botany, Brooklyn Botanic Garden, for June, *$6.00 per year, 75 cents a copy.* "The physiology of Pollen III, Growth *in vitro* and *in vivo*," R. A. Brink; "Total Acidity Compared with Actual Acidity of Plant Juices," Felix G. Gustafson; "A Physiological and Anatomical Study of the Leaves of *Polypodium Polypodioides*," Louis J. Pessin; "A Consideration of the Species *Citrus Maxima* (Burm.) Merrill," Elmer D. Merrill and H. Atherton Lee; "The Helminthosporium Disease of Rice Occurring in the Southern United States and in the Philippines," Gerardo O. Ocfemia; "The Plant Formations on the Coral Reefs Along the Northern Coast of Cuba," J. C. Th. Uphof.

American Mathematical Monthly, Ann Arbor, Mich., for June, *$5 per year, 60 cents a copy.* "The Mathematical Association," W. D. Cairns; "A Second Budget of Exercises on Determinants," Thomas Muir; "The Trigonometry of Correlation,"'Dunham Jackson; "A Theorem in Thermodynamics," J. E. Trevor; 'On the Solution of Algebraic Equations with Rational Coefficients," Glenn James; "A New Method for the Determination of the Group of Isomorphisms of the Symmetric Group of Degree *N*," H. A. Bender; "Questions and Discussions: 'An Elementary Solution of a Problem of Diophantus,'" H. E. J. Curzon; "A Note on Checking a Solution of a Triangle" E. J. Moulton; "On the Treatment of Maxima and Minima in Calculus Texts," A. A. Bennett."

Condor, Eagle Rock, Calif., for July-August, *$3.00 per year, 50 cents a copy.* "The Starling Family at Home and Abroad (with frontispiece)" Casey A. Wood; "Banding White Pelicans (with map)", Henry B. Ward; "Vigor, Distribution, and Pigmentation of the Egg," Charles K. Averill; "The Common Loon in Alberta (with two photos)" A. D. Henderson; "Weights of About Three Thousand Eggs," Wilson C. Hanna.

Education, Boston, Mass., for February, *$4.00 per year, 40 cents a copy.* "The Humanities Versus the Utilities," Florence M. Bennett; "The Selective University," Robert Henderson; "The Real South Africa," Stephen G. Rich; "Some of My Worst Teaching Mistakes," A School Principal; "Health Habits, Related Knowledge and Problems of Health," (concluded), Percival M. Symonds.

Nature Magazine, Washington, D. C., for August, *$2.50 per year.* "Trailing a Cougar," "The Water That Falls from the Sky," "Actaeon—A White-Tailed Deer," "A Wood Duck Adventure," "Tannin for Strengthening Leather," "Pelican Photographs," "Great Volcano in Eruption," "North American Orchids," "Survivors of a Glorious Past," "Mill or Meadow," "Camping in the Palisades State Park," "Dragon Flies and Damsel Flies," "Nature and Human Nature," "A Wonderful Bird Songster."

National Geographic Magazine, Washington, D. C., for August, *$3.50 per year, 50 cents a copy.* "Discovering the Oldest Statues in the World," with 26 illustrations, Norbert Casteret; "Adventurous Sons of Cadiz," with 37 illustrations, Harriet Chalmers Adams; "Moorish Spain," 26 Autochromes Lumière, Gervais Courtellemont; "From Granada to Gibraltar—a Tour of Southern Spain," with 23 illustrations, Harry A. McBride.

Photo-Era Magazine, Wolfeboro, N. H., for April, *$2.50 per year, 25 cents a copy.* "The Photographer's Daily Dozen," W. L. Hartshorn: "A Story of Dirt," William L. Woodburn; "The Appalachian Mountain Club," Parker B. Field; "Kinematography for the Amateur," Parts VII and VIII, Herbert C. McKay; "Reflections," The Camera (Dublin); "Ausable Chasm, The Adirondacks, New York," L. J. Creegan; "Trimming and Mounting the Print," G. C. Weston; "Coloring Prints with Oil-Colors," Part I, William S. Davis.

Popular Astronomy, Northfield, Minn., for August-September. *$4.00 per year.* "Eratosthenes, No. 6, Migration of the Plats," with Plates XVI, XVII, and XVIII, William H. Pickering; "Dedication of the 20-

Inch Equatorial Telescope of the Chabot Observatory to Charles Burckhalter, May 18, 1924," "Completion of the Henry Draper Catalogue," Harlow Shapley; "The New Calendar of the Eastern Churches," Miriam Nancy Shields; "The Shadow Bands of Total Eclipses," Charles S. Hastings; "Observation of the Heavens," Frederic R. Honey; "Polar Mountings for Refractors and Reflectors," C. J. Larson; "The Reform of the Present Calendar," H. Jameson; "The Distribution of the Stars," Harlow Shapley.

Scientific Monthly, Garrison, N. Y., for July, *$5.00 per year, 50 cents a copy.* "The Master Key," Dr. Paul R. Heyl; "The Origin, Nature and Influence of Relativity," George D. Birkhoff; "The Mississippi Gulf in the Middle and Upper Eocene," Edward W. Berry; "Skidding on the Road to Science," F. W. Hodge; "The Need of an International Mind," R. D. Carmichael; "Four Generations of Memorable Botanists," William Trelease; "The Next Science," Arland D. Weeks; "Immigration and the Declining Birthrate," Dr. Maurice R. Davie; "The Development of Geologic Science," H. L. Fairchild.

Torreya, Lancaster, Penn., for May-June, *$1.00 per year, 30 cents a copy.* "The Man-of-the-Earth or Wild Potato Vine," O. P. Medsger; "Alpine Plants of Kashmir," Ralph R. Stewart; "A Fossil Celtis from Colombia," Edward W. Berry; "Fungi at Woodstock," W A. Murrill.

Weather Review, Washington, D. C., for April, *$1.50 per year, 15 cents a copy.* "Hailstorms in Michigan, 1920-1923," D. A. Seeley and R. B. Dole (8 Fig.); "Hailstorms Observed in Budapest, July 13, 1922," A. Réthly (Fig.); "Tornadoes from Arkansas to Virginia, April 29-30, 1924," H. C. Hunter; "Variations in the Hourly Rainfall at Lincoln, Nebr.," H. G. Carter (8 Fig.); "Hourly Precipitation at Topeka, Kans.," S. D. Flora (Fig.); "Thunderstorm at Memphis, Tenn., April 29, 1924," A. R. Long (Fig.); "Frost in the Cranberry Bogs of New Jersey," G. A. Bliss; "Weather During April 21-26, 1924, and the Free-balloon Flights of April 23-25," V. E. Jakl (3 Fig.); "New Standards of Anemometry," S. P. Fergusson and R. N. Covert; "Why Hardwoods do Not Grow Naturally in the West," J. A. Larsen; "Temperature Summations with Reference to Plant Life," G. A. Pearson (3 Fig.); "Our Present Knowledge Concerning Atmospheric Disturbances of Radio-Telegraph," L. W. Austin; "Severe Winters in Southern Germany and Switzerland since the Year 1400, Determined from Severe Lake Freezes," J. Maurer. Translation.

MONOPOLY ON TORNADOES HELD BY AMERICA.

Tornadoes, such as the one which left a path of death and destruction in Ohio recently, are a strictly American product, according to Dr. W. J. Humphreys of the U. S. Weather Bureau. This type of storm is very rare in other parts of the world and almost unknown in Europe.

The middle Mississippi valley is the region in which they are most prevalent. They are very rare in and east of the Appalachian Mountains, but are known in greater or less intensity in every part of the country east of the Rocky Mountains. None are recorded from the Pacific coast.

The exact conditions productive of tornadoes are not known. It has been observed, however, that they most frequently occur in the southeastern part of large circular storms and on the eastern part of V-shape storms.

Just as cross-currents produce whirlpools in swiftly moving water, so tornadoes are produced by cross-currents of wind. The waterspout observed over the lake during the Ohio storm was merely the tornado passing over the water. The only difference between a waterspout and a Kansas twister is that the whirling winds are passing over water instead of land.—[*Science Service.*

ILLINOIS STATE ACADEMY OF SCIENCE.

Council Meeting.

Elgin High School, May 1, 1924.

The Council met with the Local Committee of Arrangements at the High School Building, Elgin.

Final arrangements for the Annual Meeting were discussed and all plans completed.

New names were presented for membership. The list of names was approved by the Council, and it was voted to recommend the Treasurer's list of new members to the Academy for election.

A letter from the British Association of Science was read, in which an invitation was extended to our Academy of Science to attend the Science Convention to be held in Toronto, August 6-13, 1924. It was recommended that the incoming Council appoint delegates to the Toronto Convention from among those members of our Academy who were planning to attend.

Adjourned.

C. F. PHIPPS,
Secretary.

Annual Business Meeting.

Elgin High School, May 2, 1924, 8:45 a. m.

President W. G. Waterman presided, and, after calling the meeting to order gave a brief report concerning the printing and distributing of the leaflets on the work and aims of the Academy. A copy of the leaflet had been sent previously to each member of the Academy.

The Treasurer submitted the following report:

REPORT OF THE TREASURER FOR THE YEAR 1923-1924.

Receipts.

Balance on hand, May 1, 1923	$ 459.97
From Local Dues	130.00
From National Dues	332.50
For Reprints	176.61
For Transactions	21.00
Total	$1,120.08

Disbursements.

Reprints, Printing Bill	$ 156.20
Collected for A. A. A. S.	32.00
Refunded Dues	13.00
Expense of President's Office	56.35
Expenses of Secretary's Office	351.26
Expenses of Treasurer's Office	48.74
Secretary's Salary	150.00
Total	$ 807.55
Total Receipts	$1,120.08
Total Expense	807.55
Balance on hand	$ 312.53

The report was accepted by vote and referred to the auditing committee. The Membership Committee, through its Chairman, Clarence Bonnell, reported that 34 new names had been approved by the Council for membership. After reading the list of candidates a vote was taken electing them to membership in the Academy.

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The Librarian, A. R. Crook, handed in a written report, which will be printed in full, in the transactions.

Chairman John C. Hessler, of the Committee on High School Science and Clubs gave a report on the year's work, and this Committee's report will be published in full in the transactions.

The report was accepted.

The Secretary reported that Vol. 16 of the Transactions had been published and sent out to all members, and about 400 copies remained in the Librarian's keeping. Also reported that such reprints of the Galesburg papers as had been ordered were now in the press and would soon be issued. Report was accepted.

Chairman W. S. Bayley, of the Committee on Affiliation, reported progress, and stated that the Committee had attempted to secure a census of the Scientific Societies of the State, but was unable to do so. It was difficult to locate any scientific societies not already affiliated with the Academy. Members were urged to notify the Committee if any local scientific societies were known to them. Report accepted.

The following plan for affiliating local scientific societies was presented in two parts.

Part I.

Local Academies of Science and similar Scientific Societies in the State other than High School Science Clubs, may become affiliated with the State Academy by an affirmative vote of three-fourths of the members of such society, when confirmed by vote of the members of the State Academy at their annual meeting. Voted to adopt.

Part II.

Members of such affiliated societies may become members of the State Academy without initiation fee, by paying annual dues to the treasurer of the local society sufficiently large so that the local treasurer may send to the treasurer of the State Academy one dollar for each member, except for life members of the State Academy, or for whose who are also members of the A. A. A. S. Voted to adopt.

Amendments.

Several amendments to the Constitution were presented as follows:

(1) An amendment to Article V, allowing two past-presidents, instead of one, to sit with the Council. The article as amended in the first sentence reads as follows: The Council shall consist of the President, Vice-President, Secretary, Treasurer, Librarian, the retiring President and his immediate predecessor.

(2) An addition to Article V.—"At the Annual Meetings the presiding officers of all the affiliated scientific societies of the State shall meet with the Academy Council for the discussion of policies."

(3) An addition to Article VI, providing for a Committee on Affiliation, consisting of five members chosen annually by the Academy.

(4) An addition to Article IV, providing for the selection of a second vice-president.

Said officer may be a resident of the town in which the next annual meeting is to be held, and may be appointed by the Council each year when the next meeting place shall have been decided upon.

The above amendment and additions to the constitution were separately adopted by vote.

The Illinois Nature Study Society of Elgin applied for affiliation with the Academy, and by vote such affiliation was granted.

The President appointed the following committees, to report at the business meeting to be held at five o'clock in the afternoon.

Committee on Nominations—A. R. Crook, Chairman; H. C. Cowles, Mary M. Steagall, L. E. Hildebrand, J. C. Hessler.

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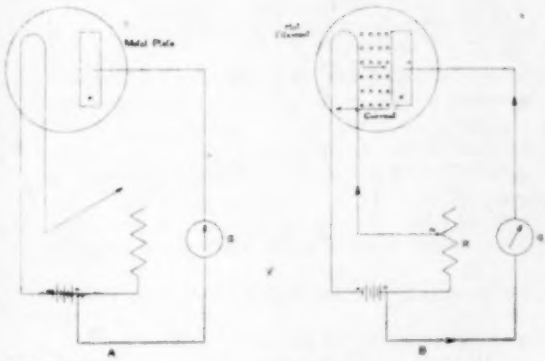

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Committee on Resolutions—W. S. Bayley, Chairman; F. R. Jelliff, F. M. Colyer.

Committee on Auditing—W. H. Packard, Chairman; G. W. Boot, C. M. Turton.

A motion was passed that a Committee on Conservation be added to our standing committees. By vote the incoming Council was empowered to appoint such a committee on Conservation for the coming year.

A letter was read from the British Association of Science inviting our Academy to send delegates to their meeting to be held in Toronto, August 6-13, 1924. It was voted that the recommendation of the Council, in session May 1, that delegates be appointed by the incoming Council, from among those who were to attend the Toronto meeting, be accepted.

Adjourned to meet at 5:00 p. m.

Business Meeting.

Elgin High School, 5:00 p. m., May 2, 1924.

President Waterman presided. Report of committees called for.

W. H. Packard reported that the Auditing Committee had examined the books and accounts of the Treasurer and had found them correct. Report accepted.

W. S. Bayley, for the Resolutions Committee, reported as follows on the death of members during the year:

It is with sincere regret that the Academy records the passing away during the past year of the following members:

Mr. C. B. Caldwell, Lincoln State School and Colony, Lincoln, Ill.
Mr. Theo. O. Edgar, Dixon, Illinois
Mr. J. H. Jones, Evanston, Illinois
Mr. L. H. Hyde, Joliet, Illinois
Prof. Alexander MacGillivray, Urbana, Illinois
Mr. Chas. F. Millspaugh, Field Museum, Chicago, Illinois

Resolutions accepted by vote.

Also the Committee presented a resolution of thanks to all persons and organizations in Elgin who had helped in any way to make our meeting a success.

This resolution was adopted and it will be printed in full in the Transactions. Copies were sent by the Secretary to all in Elgin concerned in making our meeting a success.

A third resolution was presented concerning the practice of polluting the streams and rivers of Illinois, and recommending reformatory action by the State legislature.

This resolution was adopted, and will be printed in full in the Transactions.

The Committee on Nominations reported as follows:

Nominations for Officers for 1924-25: President, W. G. Bain, Springfield; Vice-President, C. H. Smith, Chicago; Secretary, C. F. Phipps, DeKalb; Treasurer, W. B. McDougall, Urbana; Librarian, A. R. Crook, Springfield.

Nominations for Committee on Membership: B. K. Richardson, Springfield, Chairman; W. H. Packard, Peoria; J. H. Bretz, Chicago; T. E. Savage, Urbana; Miss Alice Patterson, Normal.

Nominations for Committee on Affiliations: W. S. Bayley, Urbana, Chairman; Mrs. Eleanor Smith, Joliet; M. H. Leighton, Urbana; W. G. Waterman, Evanston; C. A. Shull, Chicago.

Nominations for Third member of Publication Committee: L. E. Hildebrand, Kenilworth.

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The report of the Nominating Committee was accepted, and the Secretary was empowered to cast the ballot of the meeting for the officers and committees nominated. This was done and the officers and committees named were declared elected.

The Treasurer reported five new candidates for membership, and they were duly elected.

Meeting adjourned.

The papers presented at the general meetings and section meetings were very much enjoyed by the members and visiting friends. As nearly as could be calculated there were from 150 to 200 Academy members present and possibly as many visitors. The total attendance at the section meetings Friday afternoon was about 200, but this number was much increased by visitors at the general meetings. There were 73 papers presented in the seven section meetings and three General sessions. The Academy was welcomed by Mayor Earle R. Kelly on Thursday evening in a very cordial address.

On Saturday, May 3, many members and friends met at the High School to participate in the field trips. One group visited the Elgin Watch factory and were shown through the various departments and had the details of making a million watches a year explained. After the tour of inspection the Watch Company's Astronomical Observatory was visited where it was learned how accurate time is obtained from the stars every night.

A second group, led by Dr. M. M. Leighton and Dr. Paul MacClintock, visited interesting regions of glacial deposits near Elgin.

The third group, led by Dr. H. C. Cowles, made a study of plants and trees in Trout Park. The White Cedar swamp was of especial interest, since it is a relic of the glacial age and has no counterpart elsewhere in the state.

All these groups met at noon in Trout Park where they were served a bountiful complimentary luncheon by the Illinois Nature Study Society of Elgin. This courtesy was much appreciated by the members.

In the afternoon the Geology group continued its exploration of the glaciated regions, and the Botany group visited Hill's famous Evergreen Nursery at Dundee.

Concerning the Elgin meeting as a whole, many of the members voiced the opinion that it was a gratifying success, and that it was one of the best the Academy had ever held.

C. FRANK PHIPPS,
Secretary.

Minutes of the Educational Press Association.

1924

The annual meeting of the Educational Press Association scheduled for Wednesday, February 27, was held at the Hamilton Club in Chicago at 6:00 o'clock p. m.

The meeting was called to order by President Arthur Chamberlain, Editor of the Sierra Educational News. The program as arranged was carried out.

Dr. George D. Strayer of Columbia University gave a very splendid address on the "Results of the Educational Finance Inquiry," calling attention to the volumes already published and to the very fine information contained in them in regard to tax systems and support for the public schools.

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Dr. Chamberlain reported the results of the year's activity in California where the Governor of the state had made a serious attack on the cost of schools. The school people, organized through the California Teachers Association, had succeeded in maintaining the position which had been attained after years of very hard, continuous effort.

"The Place of the Educational Press in Developing Support for Public Education" was discussed in a very excellent paper by Dr. Frank A. Weld of the American Educational Digest. This paper was so well received that on motion of Mr. Walker, Editor of School and Community, and by unanimous vote it was ordered printed and distributed to the membership of the Educational Press Association.

Joy E. Morgan, Chairman of the Committee on Standards for Educational Journals, made a report for the Committee. This report was received and the recommendations contained in it were approved by unanimous vote. These include the reprinting of the leaflets on Standard Sizes and the continuation of the Committee to make a further study of problems relating to advertising, including rates, proportion of advertising to reading, arrangement of advertising, ethical standards involved, and undeveloped opportunities in advertising. The complete report of the Committee is included in these minutes.

On motion duly made and seconded, the following resolution was unanimously adopted: Resolved that the Educational Press Association of America endorse the Sterling-Reed Education Bill now before Congress and urge its members actively to promote the passage of this measure.

The Treasurer's report, submitted by Treasurer M. P. Helm, was read and on motion approved and ordered filed in the minutes of the Association. The Treasurer reported unpaid dues for 1924 amounting to $125. as a resource of the Association in addition to balance shown by his annual statement.

Twenty-six members were in attendance at the dinner as follows:

A. H. Chamberlain, Sierra Educational News.
James H. Kelley, Pennsylvania School Journal
D. E. Robinson, Utah Educational Review
J. W. Searson, American Educational Digest
Frank A. Weld, American Educational Digest
George L. Towne, American Educational Digest
B. E. Dill, American Educational Digest
C. C. Meyer, American Educational Digest
M. P. Helm, Educator-Journal
O. S. Deming, Southern School Journal
Chas. A. Bennett, Industrial Education Magazine
L. L. Simpson, Industrial Education Magazine
N. Guy Wilson, Educational Publishing Company
E. S. Smith, Educational Publishing Company
C. H. Smith, School Science and Mathematics
C. M. Turton, School Science and Mathematics
J. C. Isenbarger, School Science and Mathematics
J. A. Nyberg, School Science and Mathematics
H. E. Cobb, School Science and Mathematics
W. E. Tower, School Science and Mathematics
J. R. Fuvell, Educational Advance
Joy E. Morgan, Journal of the N. E. A.
Chas. F. Pye, Midland Schools
E. M. Carter, School and Community
Thos. J. Carter, School and Community
E. M. Hosman, Nebraska Educational Journal

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The following officers were elected for the ensuing year:
President—Arthur Chamberlain
Secretary—George L. Towne
Treasurer—M. P. Helm
Executive Committee—Joy E. Morgan, Chas. F. Pye.

After discussion and approval by the Association, the President announced that a conference of the Association would be arranged at Washington during the meeting of the National Education Association.

On motion duly made and seconded, the Association adjourned.

GEO. L. TOWNE, Secretary.

Southern California Science and Mathematics Association.

Minutes of the General Meeting Friday, December 21, 1923.

President Weatherby called the meeting to order at one-thirty. Attendance was excellent despite the fact that this meeting was held during the last half-day session of Institute week. It was also the fifth meeting of many members of the association during the week; for this year, for the first time, we had a series of correlated science talks and a real scientist to give them on five different days, and every talk counted as a regular session of Institute and could be substituted for the more general addresses usually attended. Many remarks of approval were heard and attendance certainly justified repeating the arrangement for future Institutes.

President Weatherby spoke of this and also of the fact that he had tried to have four meetings of the Association this year, and had succeeded in having three—the evening session at Lincoln High, the afternoon session at Southwest Museum, and this excellent series of talks at Institute. The meeting that was to have been held at Thanksgiving time had to be given up as the speaker was called away to Santa Maria.

He complimented the program committee under Mr. Sandifur and recommended that their work be continued by a committee appointed by the new president.

The Committee on Chemical Industries and Resources of Southern California announced it would have a complete report to make in the near future. Mr. Ross made a preliminary report of the work done so far and said he hoped that 500 copies of the final report should be mimeographed or printed. 150 firms have been interviewed.

Miss Willson moved that Mr. Ross should be allowed to bring his excellent work to a close, and, with the approval of the Executive Committee, be allowed to publish (a 20-25 page pamphlet probably), the results of this work. The motion was seconded.

President Weatherby then called for the report of the Committee on Resolutions—Mr. Ross and Mr. Moore. The report was as follows:

Dr. Dayton C. Miller, Professor of Physics, Case School of Applied Science, Cleveland, Ohio, has delivered during this week Dec. 17-21, 1923, a series of five lectures before the members of the Southern California Science and Mathematics Association. The lecture subjects have been "Sound Waves and Methods for Recording and Photographing Them," "Noises and Non-Musical Sounds," "Acoustics of Auditoriums," "Tone Qualities of Musical Instruments," and "Physical Characteristics of the Sounds of Speech."

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means of this instrument he has shown the phenomena of sound waves in such a manner that it has a more real and vivid meaning.

Dr. Miller in a sixth lecture has reviewed some of the work on light interference phenomena and has given a very interesting account of his own researches in the field of "Ether Drift." He has stated some premises of the Einstein Theory in language that the layman can appreciate.

The subject-matter of these lectures has been that of a master, has been told in a most scholarly manner, and yet has been stated in a simple, straight-forward language. It is such efforts, by men who know, that place the results of science before the world in such a manner that those persons who are not scientifically trained, as well as those who are, may profit by scientific research.

Now, therefore, Be it Resolved, that we, the members of the Southern California Science and Mathematics Association, express to Dr. Dayton C. Miller our sincere appreciation of the information and inspiration which he has brought to us.

Second, Be it further resolved that a vote of thanks be extended to Dr. Susan Dorsey, Superintendent of Schools of Los Angeles, Mr. Robert H. Lane, Mr. Walter B. Crane, President C. T. A., So. Section, and other officers of the institute for their support in securing the series of separate science meetings.

Third, Be it resolved that Mr. C. W. Sandifur and other members of the Science and Mathematics Association committee be thanked for their untiring and successful efforts to secure the granting of a series of science lecturers and meetings, and for their work in completing and carrying out the program.

Also that a copy of these resolutions be incorporated in the minutes of this meeting, and that a copy be delivered to Dr. Miller, Dr. Dorsey, and other officers mentioned above.

Signed, V. R. ROSS
M. S. MOORE.

Mr. Fluckey next gave the report of the nominating committee—Messrs. Fluckey, Mitchell, and Ross—

For President: Mr. C. W. Sandifur of Hollywood High School.

For Vice-President: Miss Abbie O. Stoddard of Pasadena High School.

For Secretary-Treasurer: Mr. J. S. Goldthwaite of Lincoln High School, Los Angeles. The report was accepted and these officers were elected by acclamation.

Mr. Sandifur gave a brief address. He thanked the Association for the honor given him, and said he hoped so to conduct his office that it would be considered a great honor. He also hoped, with the backing of the Association, to give them what they wanted, and asked for their support, effort and ideas.

It was moved and seconded to authorize Miss Willson to make the expenditure for a box of fruit for Dr. Miller to accompany the Association's farewell and good wishes for a pleasant and comfortable trip back to Dayton, Ohio.

The motion was made to adjourn to hear the last of Dr. Miller's lectures.

Section-Meetings.

Two Sections held special meetings during Institute: Mr. Just of Long Beach High was elected Chairman of the Physics-Chemistry Section; Miss Mary C. Miller of Los Angeles Polytechnic High was elected Chairman of the Diology Section with Mrs. G. D. Houk of San Pedro, Secretary. Officers of the Mathematics and General Science Sections will have to hold over until others are elected.

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Eight power projects on the navigable rivers of the United States have been completed since the American Government inaugurated its policy for the development of the navigable waters under its control, Col. Charles Keller of the U. S. Army said in addressing the World Power Conference at London recently. Among the great power developments upon rivers in the United States mentioned were the Hudson river at Troy, N. Y., the Black Warrior River, Alabama, the Mississippi River above Minneapolis and St. Paul, and Muscle Shoals, on the Tennessee River, Alabama, not yet fully developed. All of these are U. S. Government operations, involving an expenditure of $50,000,000. The power plant at Keokuk, Iowa, is an example of successful private development built at a cost of nearly $20,000,000. This plant produces cheap electric power and substantially benefits river traffic in that part of the Mississippi River.

This development of river power is not rapid, Colonel Keller stated. The rights of navigation in early days were very carefully guarded; later the diminishing importance of river traffic encouraged plans to develop power at the expense of the public interest. Undue encroachment was checked by presidential veto during the administration of Theodore Roosevelt. Since the passage of the Federal Water Power Act in 1920, and the better adjustment of navigation and water power interest a progressive utilization of the power resources of our navigable streams is to be expected, Colonel Keller said.—[*Science Service.*

BOOKS RECEIVED.

New England Association of Chemistry Teachers Twenty-Fifth Anniversary, L. R. Atwood, Secretary, 1924. 64 pages, 15x22 cm., paper, 114 Wyoming Avenue, Mauldin, Mass.

Allyn & Bacon, pages 181 plus XVI, 13x19 cm., paper, 1924. Allyn & Bacon, Boston, Mass.

Laboratory Physics, by E. H. Johnson, Kenyon College, pages VIII plus 322, 14x19 cm., cloth, 1924. Harcourt Brace & Company, New York.

Essentials of Solid Geometry, by David E. Smith, Columbia University Pages LX plus 238, 13.5x19 cm., cloth. 1924. $1.25. Ginn & Company, Boston, Mass.

Problems in General Physics, by Morton Masins, Polytechnique. Worchester, Massachusetts. Pages X plus 154, 14x21.5 cm. Cloth. 192. $2.00. P. Blakiston's Son & Company, Philadelphia.

Chemistry Experiment Sheets, by Mortin Merdel, Jamaca High School, New York, Milton B. Brundage, Stuyvessant High School, New York City. Pages 120, 21x27.5 cm., cloth. 1924. Fordham Publishing Company, New York City.

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Reference Studies in Medieval History, by James W. Thompson, University of Chicago. Parts One, Two, and Three. Part One, pages 36 plus 79. Part Two, pages XII plus 151. Part Three, pages 11 plus 113—13 by 20 cm. Paper. 1924. University of Chicago Press.

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Our Physical World, by Elliot R. Downing, University of Chicago. Pages XVIII+367, 14x20 cm. Cloth. 1924. $3.50. The University of Chicago Press.

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Elementary Algebra by Elmer A. Lyman, Ypsilanti, Mich., and Alburtus Darnell, College of the City of Detroit, Detroit, Mich. 336 pages. 13x19 cm. Cloth. 1924. American Book Co., Chicago.

This book covers the topics ordinarily given in a first course in high school algebra, including a very brief introduction to variation and numerical trigonometry. The authors have not attempted to make the book one in so-called correlated or unified mathematics. However, it has been designed to meet the requirements of the College Entrance Examination Board which it essentially does.

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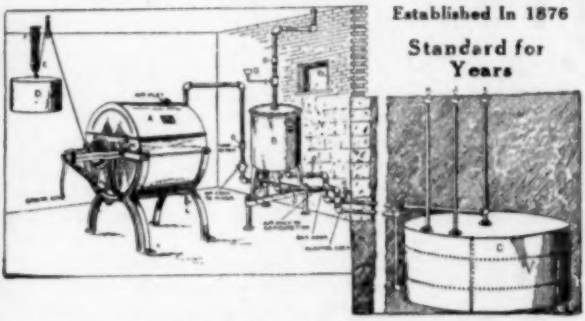

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introducing negative numbers. A large variety of problems are given which pertain to simple geometric figures; and the more difficult problems of all types have been omitted. Because of this latter fact, it is proper to say that the book does not fulfill the maximal requirements of a first year course in algebra. Rules of procedure in solving types of problems are far the most part well stated. Little drill, however, is given in translating sentences and phrases into algebraic symbols, except as is given in solving stated problems. That is to say, the writer feels that as early as possible the pupils should be drilled to establish the proper orientation in this respect. To summarize, there is much that leads one to believe that the book is quite teachable.

E. S. L.

Farm Woodlands, a text book for students of agriculture. A hand book for practical farmers; by James Berthold Berry, M. S. County Vocational Supervisor, Pennsylvania. Cloth. Illustrated with 163 figures in the text. 425 pages, size 13x18 cm. Published by the World Book Company. 1923.

This is a companion of the book, "Northern Woodlot Trees," a guide to farm lot trees by the same author and recently reviewed in this Journal. These two books fill a real need for a handbook and guide to the trees of the farm simple enough for beginners in vocational studies and containing the information needed for wise scientific care of farm lots. The content and scope of the book may be indicated by the following extracts of titles of chapters. "Forest Influences"; "The Forest Situation in the U. S."; "Determining the Area of the Woodlot"; "Stock-taking"; "The Improvement Cutting"; "Utilizing Woodland Products"; "Woodland Plans"; "Woodland Accounting"; "The Farm Nursery"; "Shade Trees and Their Care." These few extracts show that the book is comprehensive in its content, including all the information needed for an elementary understanding of the forestry problems of the small woodlands of the farms of this country. We heartily recommend the book to those interested in such work.

W. W.

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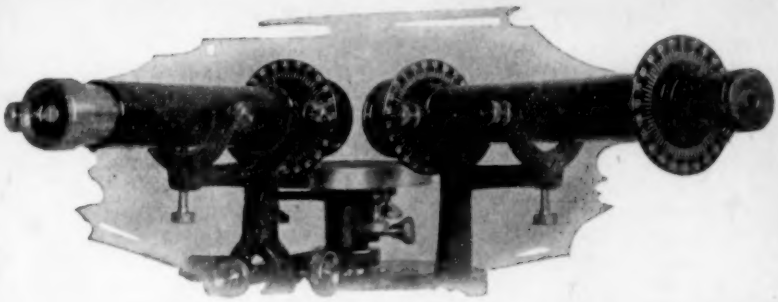

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W. H. C.

Reference Studies in Medieval History, in three parts, by James W. Thompson, University of Chicago. Pages XXXVI+XII+XI+342, 13x20 cm. Paper. 1924. The University of Chicago Press.

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